INDUCTIVE LOGIC MADE EASY

BY

S. C. SEN, M A., B L.,

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INDUCTIVE LOGIC MADE EASY.

(Adopted to the I. A. Syllabus of the
Calcutta University).

BY

S. C. SEN, M.A., B.L.

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PREFACE.

The special features of this manual justifying its appearance in an already crowded market may briefly be indicated as follows —

1 It is in the question and answer form, answering all the C U Questions—B A (both pass and honours) and I. A ,—of the last twenty-seven years, from 1897 down to 1923 Answers are full, and yet concise

2 It fully covers the I A syllabus. In order to that end many questions besides the University questions have been raised and answered.

3 Though in the question-and-answer form, it is a systematic one All the questions have been systematically arranged in different chapters, with an eye upon the syllabus Questions are all numbered, and clear references are given in the syllabus , so that the students will experience no difficulty in finding out which topic of the syllabus is discuss ed in which question or chapter

4 Full justice has been done to the most important, but oft-neglected, chapters on Experimental Methods and Inductive Fallacies All the fallacies have been fully explained and exemplified Directions are given as to how to test an argument , and all the arguments asked in the University are fully tested

5 A chapter has been added at the end answering all the questions asked in the University to test the intelligence of the boys

6 The important questions are marked with asterisks

7. The style is easy and lucid, intelligible even to a careless reader

No pains have been spared to make the manual an improvement upon all the existing books and notes in respect of both matter and manner Every care has been taken to meet in all respects the requirements of the boys preparing for the I. A. Examination.

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Syllabus in Inductive Logic for the Intermediate Examination. (with References)

Material Logic : Nature of Truth Knowledge and Reality Sources of Knowledge · Perception Inference · Authority [Chap. I]. Necessary Truth (Chap XVI).

Generalisation and the General Idea (Q 12) Science [See Deductive Logic]. Laws of Nature [Chap. X.] Uniformity of Nature. [Chap III]

The grounds and Conditions of Inductive Inference [Chap III, IV, and V] Origin of belief in Universal Causation (Q 28). Energy and Conservation (Q 35) Causes and Conditions (Q 32) Plurality of Causes (Q 30) Composition of Causes and Intermixture of Effects (Q 33).

Discovery and Proof (Q 70) Hypotheses, their uses and conditions [Chap XII] Theory. (Q 123) Verification (QQ 77, 78, and 125). Observation and Experiment, and their uses [Chap V] The Experimental Methods and their uses, with examples of their application. [Chap. VI] Fallacies of Observation (Q. 175)

Nature, place and use of the Inductive method (QQ 13 14, and 15). Perfect and Imperfect, Complete and Incomplete Induction (QQ 18 and 22) Inference from Analogy [Chap IX] Inference from Simple Enumeration (Q 17) Inductive Probability (Chap VIII) Chance and its Elimination (Q 88) Scientific Induction (Q. 17). Processes Simulating Induction [Chap II] Fallacies in Inductive Reasoning [Chap XIX]

Classification, Natural and Artificial, and its conditions [Chap XIII] Relation of Classification to Division (Q 137). Definition and its material conditions , Description. [Chap XIV] Type (QQ 140 and 145) Errors in Classification and Definition (Q 175). Terminology and Nomenclature. [Chap. XV].

Nature, place and use of the Deductive Method. [Chap. VIII]. Relation of Induction and Deduction (Chap XVIII) Nature, function, and value of the Syllogism, [Chap XVIII] Inductive and Deductive Sciences (Q 174). The actual Method of Scientific Progress (Q. 76) Demonstration [Chap XVI]. The World as a System of Laws. (Q. 102).

Explanation and its Limits. [Chap. XI]

INDUCTIVE LOGIC

MADE EASY.

N B Important questions are marked with asterisks.

CHAPTER I.

TRUTH AND KNOWLEDGE

1 Q. *What is truth? Distinguish between Formal and Material Truth Which of them constitutes the proper subject-matter of Logic?* (*I A*, *18*).

A The term *truth* is employed at least in two different senses, *viz*, *formal* and *material* Formal truth consists in the consistency of thoughts among themselves, no matter whether they conform to reality or not. In as much as in Logic the term *thought* is taken to include concept, judgment, and reasoning, formal truth means the consistency of concepts, of judgments, and of reasonings among themselves Since thoughts find expression in words, formal truth necessarily means the consistency of terms, of propositions, and of inferences among themselves Thus, the term "immortal man" is formally quite true, for it does not involve any self-contradiction But the terms 'circular square', 'wise fool,' 'falsely true,' 'reasonably absurd,' 'triangular circle,' 'curved straight line' 'living corpse,' and the like, are formally incorrect, for they are self-contradictory Again, the propositions 'Man is immortal,' 'The sun rises in the west,' and the like, are not formally wrong But the propositions "Immortal Hanumana has died,' 'The ferocious tiger is a gentle creature, and the like, are formally incorrect. Lastly, the reasoning "all men are crows , Ram is man , therefore, Ram is a crow" is formally valid. But the reasoning "All men are mortal; therefore all mortals are men " is formally invalid, for the conclusion is not in harmony with the premiss

Material truth, on the other hand, consists in the agreement of thought with reality, that is to say, in the correspondence of our concepts (hence terms), judgments (hence propositions), and reasonings (hence arguments) with actual facts Thus, the term 'immortal man' is materially false, for we can nowhere find an immortal man, and so the term does not agree with the fact Again, the propositions 'Man is immortal,' 'The sun rises in the west,' and the like, are materially false, though formally valid Lastly, the reasoning 'All men are crows : Ram is a man therefore, Ram is a crow ' is ~~materially~~ invalid, for it does not harmonise with reality

N B—Formal logicians *e g*, Hamilton, Mansel, and Whately, take the term *truth* in the formal sense, while material logicians, *e.g* Mill and Bain, in the material sense.

Relation—Formal and Material Truth —From the examples given above we can easily gather the relation of formal and material truth We can state two propositions indicating their relation —(1) What is materially true is formally true, but what is materially false may not be formally false Thus the example of crows given above is materially false, but formally quite valid (2) What is formally false is materially false, but what is formally true may not be materially true Thus the terms 'circular square', etc , mentioned above, which are formally false, are also materially false But the example of crows given above is formally true, but materially false

(For the latter part of the question, see Q 4.)

2 Q *What is Reality* ?

A *Reality* is an abstract term meaning *existence*, as opposed to mental representation But when we speak of the agreement of our ideas with reality, we use the term in the concrete sense, so as to mean *anything existent* Whatever exist apart from our representations are therefore real Thus, the table before me, the paper I write on, the pen I write with, and the like, are real, because they all exist A centaur, a golden mountain, and the like, are unreal,because they do not exist When I am angry or afraid, the state of anger or fear is real, because it exists in my mind Reality may thus be external or internal, material or mental When, therefore, we speak of our ideas as conforming to reality, we mean both external and internal reality.

N B--It should be noted that in ordinary Logic the term reality is not taken in its ultimate sense, *viz*, in the sense of something which is capable of existing *by itself*. In this ultimate sense the Vedantist holds that Brahman alone is real, and the world unreal. Nor is the term to be understood here in the transcendent sense, that is, in the sense of something existing absolutely out of mind and incapable of being experienced by us In this sense Kant's things-in-themselves are real (The term reality is to be understood here in the *empirical* sense, *i e*, in the sense of something capable of being experienced by us Thus, the sun, the moon, the mountain, the dog, the cow, love, hatred, etc, are empirically real, because they are all capable of being experienced by us)

*** **3 Q** *Distinguish between Formal and Material Logic* (*B A*, 08, *F A*, 94,00, *I. A*, 12), *stating the end aimed at by each Which department of Logic is essentially formal, and which material, and why?* (*F A*, 00) *What do you understand by Formal logic?* (*I. A.*, 17)

A. Formal Logic is that which is concerned only with formal truth, that is to say, with the consistency of thoughts among themselves, without taking into account the correspondence of these with actual facts In other words, it is occupied only with the self consistency of concepts, judgments, and reasonings, and therefore with right use of terms, propositions, and inferences. The function of Formal Logic is to see (1) that we do not use any inconsistent terms, such as 'a sane lunatic,' 'a round square,' (2) that we do not use inconsistent propositions, *e g*, "All circular triangles are rectangular," "Some idiots are intelligent" and (3) that we do not draw any conclusions which are inconsistent with the premisses *e g*, "All men are mortal, monkeys are not men, therefore monkeys are not mortal." Formal Logic is not bound to look to the material validity of its propositions and arguments It is otherwise called Pure Logic or Logic of consistency

Material Logic, on the other hand, is concerned with material truth. In other words, it is not satisfied with the formal consistency of our judgments and inferences, but goes beyond, and considers whether the premisses, from which the conclusions are drawn, are themselves right or wrong Suppose we reason thus —All ruminants are herbivorous, all camels are ruminants, therefore all camels are herbivorous ' Here Formal Logic will only see if the conclusion rightly follows or not from the given premisses But Material Logic will consider whether the premisses themselves are true, or not From this it appears that Formal Logic is *conditionally* valid, *i e* its conclusions are really valid on condition the premisses are so In one sense, however, Material Logic also may be said to be formal, for the task of Logic, whether formal or material, is to ensure the correctness of the process of reasoning, either from the universal to the particular or from the particulars to the universal Material Logic is otherwise called Logic of truth

From the above account it is abundantly clear that Deductive Logic is essentially formal, for its business it is to see if the conclusions rightly follow or not from the given premisses, no matter whether these premisses are materially true or false , and that Inductive Logic is essentially material, for its business it is to look to the material truth of its premisses and conclusions

4 Q *What is the end of Logic? Are all logicians agreed about that?* (*B A* , 96)

A All logicians agree that the end of Logic is truth , but they differ as to the kind of truth aimed at by Logic Formal logicians, *e g* , Hamilton, Mansel, and Whately, hold that the end of Logic is *formal* truth Logic, they say, takes its premises from different sciences, which sciences are to consider the material truth of their respective propositions Logic takes them for granted, and only considers whether the conclusions rightly follow or not from them Material logicians, *e g* Mill and Bain, on the other hand, maintain that the end of Logic is *material* truth, for if we do not consider the truth or falsity of the premisses, then our conclusions are useless, though they may rightly follow from their premisses Thus we see that the two rival schools hold two different views regarding the nature of truth aimed at by Logic We may observe here that the main function of Logic is the consistency of our judgments and reasonings But we should also consider whether they agree with facts or not Hence we conclude that the primary object of Logic is formal truth, and that its secondary object is material truth.

5 Q *What is Knowledge?* (*I.A*,. 09)

A Knowledge may be defined as a system of ideas corresponding to a system of reality, accompanied by belief in such correspondence It thus consists of three factors :—

(1) It must be a *system* of ideas A single idea does not by itself constitute knowledge I may, for example, have the idea *Ram* or *mortal*, but so far I cannot be said to have knowledge of anything In order to constitute knowledge the ideas must be connected together, that is to say, I must form a judgment that Ram is mortal Again, as Kant says, every judgment is not knowledge An analytic judgment simply unfolds the connotation of the subject, and so gives no new information In other words, in an analytic judgment, *e g.* man is rational, the predicate is a part of the connotation of the subject, and as such does not say anything new about the subject Hence it follows that knowledge is constituted by synthetic judgments alone.

(2) There must be *correspondence* between our ideas and reality, that is to say, the ideas must be materially true In order, for example, to know an orange I must have ideas corresponding to its different qualities, such as its form, its colour, its taste, etc, If I be wanting in this or that idea corresponding to this or that attribute of the orange, my knowledge of the orange must be so far imperfect Again, if I think that the tiger is a tame creature, or that I am angry when in fact I am not angry, then my ideas will not amount to knowledge, for they do not harmonise with actual facts For this reason the ideas of imagination, dream, illusion, and hallucination do not constitute knowledge.

(3) There must be *belief* in such correspondence. If I have certain ideas in my mind, but entertain some doubt that these ideas may or may not correspond to facts, then they will not constitute knowledge, even if they do correspond to facts. Suppose I think that a certain friend of mine is ill. Suppose again that the friend in question is really ill. But if I do not believe that he is ill, being under the impression that my ideas may be due to imagination, then I cannot be said to have knowledge of his illness So we see that knowledge excludes doubt and uncertainty. Indeed, in order to know I must know that I know

Thus we see the elements involved in knowledge If I have no ideas corresponding to an object, I am said to be *ignorant* of it Ignorance is thus the absence of ideas Again, if my ideas do not correspond to objects, and yet I believe that they do correspond, I am said to be subjected to *error* or *mistake*. Error is much more harmful than ignorance

N B The above is only an analysis of knowledge as it exists in the mind of a subject But knowledge implies (1) the subject that knows. (2) the object that is known, and (3) the relation of the subject and the object. No knowledge is possible if there be no knower, or if there be nothing knowable Again, no knowledge is possible if the object be quite incapable of entering into relation with the subject, that is to say, if it be, by its nature unknown and unknowable

⁂ 6 Q *Explain the difference between immediate and mediate knowledge, giving examples How is it possible to advance from the former to the latter?* (*I A* ,09) *Explain fully the difference between immediate and mediate knowledge Give illustration of each When you go out in the morning and find the road in a muddy condition you believe atonce that there has been rain in the night explain what is immediate and what is mediate in your knowledge of the subject, giving your reason* (*I A* , 11) *Explain and illustrate the distinction between immediate and mediate knowledge Has Logic anything to do with immediate knowledge* (*I A* , 17)

A Immediate and Mediate knowledge — Knowledge is immediate when it is acquired directly either through the sense organs, such as the eyes, the ears, *etc*, or through introspection (otherwise called reflexion or self-consciousness) When, for example, I hear a sound, smell a rose, or see a colour, the knowledge of the sound, the smell, or the colour is immediate. Again, when introspection tells me that I am angry or afraid or that I feel pain, the knowledge of my anger, fear, or pain is immediate Thus we see that immediate knowledge may be either of outer objects or of the inner states of mind

Knowledge is *mediate* when it is acquired indirectly, *through the medium* of a third thing. When, for example, I perceive smoke in my room, I know there must be fire somewhere near-by Here the knowledge of the smoke is immediate, but that of the fire is mediate, for I know fire not directly, but through the medium of the smoke. In like manner, when perceiving *some* cases of mortality I know that *all* men are mortal, the knowledge of the mortality of *all* men is mediate, because it is gained not directly, but through the medium of some particular cases of mortality

In the given example, the knowledge of the road and of its muddy condition is immediate For, these are the facts of direct perception But the knowledge of rain in the night is mediate, for I have not directly perceived rain, but have come to know it indirectly through the muddy condition of the road

N, B—Knowledge given by perception is not necessarily immediate, for perception may be both immediate and mediate When for example, there is a mango lying at some distance from me, the perception of its form and colour is immediate, but that of its smell, taste, weight, etc, is mediate The visual perception of distance and solidity, as Berkeley says is mediate Inferential knowledge is always mediate

How to pass from Immediate to Mediate knowledge :—With a view to understand the matter let us take a familiar example. From the immediate cognition of the smoke present before me I can advance to the mediate cognition of the fire, because on former occasions I perceived them as *associated together* Had I not formerly perceived them as conjoined together, then from the one given I could not have passed on to the other not given Therefore, the passage from immediate to mediate cognition is possible owing, as Hume says, to the association of presentations But another thing is necessary for the purpose, *viz* the uniformity of nature Because fire and smoke were associated together in the past, it does not follow that they will always be associated so as to make our inference possible, unless nature is uniform in her behaviours.

Logic and Immediate knowledge—Logic being a science of inference, is directly concerned only with mediate knowledge But we know that mediate knowledge presupposes immediate knowledge I cannot, for example immediately know that all men are mortal unless I immediately know several particular cases of mortality, I cannot mediately know that there is fire in the neighbourhood unless I have immediate knowledge of smoke From this it follows that if my perceptions are wrong then the inferences based on them must necessarily be wrong. Logic must, therefore, have also to take account of perception (observation), though in an incidental way Thus we see that Logic is essentially concerned with mediate knowledge, but only indirectly with immediate knowledge, as being auxiliary to mediate knowledge We cannot, therefore, support Ueberweg when he says that Logic is interested in immediate and mediate knowledge in the same sense.

*** 7 Q *Mention and explain the sources of knowledge.*

A Three sources of knowledge are generally recognised, *viz*, (1) Perception (both external and internal) (2) Inference (deductive, inductive, and analogical) and (3) Authority or Testimony. To these three the Intuitionists add another, *viz*, Intuition. Let us briefly discuss these one by one :—

1 **Perception** —Perception is the process whereby we know objects through the senses Perception is either external or internal External perception gives me knowledge of external objects, *e g*, a table, a chair, a book, a tree, through the different sense organs, such as the eye, the ear, etc. Internal perception gives me knowledge of the states of my own mind, that is to say, by means of internal perception I know that I am angry, that I am happy, and so forth Internal perception requires no sense organ like the eye, the ear, etc

N B—In connection with perception three points should be observed, viz, that (1) perception gives us knowledge only of *particular* facts, and not of general principles I cannot for example, perceive *all* men, but only *some* men, (2) Perception gives us knowledge of what are present, and not of the past, distant, and future In other words, perception is concerned with *now* and *here*, and not with *not now* and *there* I cannot perceive what happened in the past, nor what will happen in the future, but only what happens at this moment Neither can I perceive what takes place far away from me beyond the ken of my sense organs I cannot, for example, perceive the events of the German war while I am in India. (3) Perception gives me knowledge of the states of my own mind, and not of the states of other minds For the knowledge of the states of other minds I have to depend upon inference

II **Inference** —Inference is the process whereby we pass from one or more given judgments or propositions to a previously unknown judgment or proposition, contained in or justified by them It is a passage from the known to the unknown—from the given to the not-given—from the implicit to the explicit—from the present to the past, distant, and future. It is thus a process of knowing what was unknown by means of the known on the ground of identity or similarity. Reasoning may be inductive, deductive, or analogical Inductive reasoning is that in which we pass from the less to the more general as when we infer the mortality of *all* men from the mortality of *some* men. Deductive reasoning is that in which we reason from the general not to the more general. And analogical reasoning is that in which we reason from the particular to the particular [For a detailed account of reasoning, see my Deductive Logic, Q 79]

Relation of Perception and Inference ·—Perception and inference involve each other ·—(1) Inference presupposes perception I cannot, for example, infer rain from the muddy condition of the road, unless I formerly *perceived* them as associated together Again, I cannot infer the mortality of all men, unless I have perceived the mortality of *some* men. Indeed, as Charvaka holds, inference is proximately based upon perception. (2) Perception involves inference. For example, in perceiving an orange from a distance what I actually perceive are its form and colour, the rest of its qualities, *e g*, its taste, smell, softness, etc., I infer.

III. Authority or Testimony —Testimony is a statement made upon a subject by one who is competent to speak on it. A slight reflexion will show that a minute fraction of our knowledge is derived from direct perception and inference, and that the far greater portion is derived from authority. We can perceive only those phenomena which are just present before us But they are extremely few in number, being limited in time and space. As for inference, very few people care to take the trouble of going through the irksome processes of inference, most people take to the easier course of depending upon the authority of others, either verbal or written. Thus, the historical facts of the past, the current events of the world abroad, most of our religious and moral conceptions, most of the results of scientific researches, and the like, are accepted by many of us on the authority of others.

IV **Intuition**.—This source of knowledge is mentioned only by the intuitionists, *e. g.*, Reid. Intuition is held to be a peculiar faculty partaking of the nature of both sense and reason. It resembles sense in that it gives *immediate* knowledge, and reason in that it gives *general* knowledge. Intuition is thus alleged to give us immediate knowledge of universal and necessary truths, such as the fundamental laws of thoughts, the uniformity of nature, the law of causation, and the like.

N. B.—Gotama mentions four sources of knowledge, *viz.*, Perception, Inference, Analogy, and Testimony (প্রত্যক্ষানুমানোপমানশব্দাঃ). But we know that analogy is a form of inference, and hence is to be included in it. According to Charvaka, there is but one source of knowledge, *viz.*, perception. He reduced Inference to Perception, and excluded Authority as being rather a source of false ideas.

8 Q. *"Great part of the knowledge of every individual is derived not directly from inference, nor even from perception, but from authority." Explain and illustrate this, exhibiting clearly the meaning of authority. What part of your knowledge have you derived from authority? On what conditions mainly does the value of authority depend?* (*I. A.*, *12*).

A. Conditions on which the Value of Authority depends :—

It is very difficult to ascertain which authority is competent, and which not,—which testimony is to be accepted and which rejected. All we can do is to lay down certain conditions on which the value of authority depends. They are as follows :—

1. **Directness**.—The less indirect is the testimony, the greater is its reliability. The other conditions remaining the same, the testimony of one who has himself perceived the event is better than that of one who has only heard it from another.

2. **Consistency with Experience.** If a piece of testimony contradicts actual and possible experience, we should be extremely cautious in accepting it. If, for example, a man testifies that he has seen a dead man brought back to life, we should place little reliance upon his statement, for it contradicts the course of experience.

3. **Moral character of the Witness.** For example, the testimony of one reputed to be a liar is unreliable.

4. **Numerical strength of the Witnesses.** The other conditions remaining the same, the greater the number of witnesses testifying to the same fact, the more reliable is the testimony.

5. **Disinterestedness.** A party interested in a case is hardly expected to speak the truth, if the truth goes against him. For this reason the evidence of a friend or foe is given much less credit in the law-court than that of a neutral person. [For the rest see Q 7]

9 Q *Is Authority an independent source of knowledge?*

A. Authority is ultimately traceable to perception and inference. What I take on authority from another, *e g*, the fact that the Tzar has been murdered, must have been originally perceived or inferred by some. Besides, in accepting a fact on authority I myself draw an inference. I reason thus.— Whatever such and such a man testifies must be true, because he is a reliable person (Major). He testifies that such and such a thing has happened (Minor). Therefore it is true that it has happened (conclusion). Thus we see that authority is really a form of inference and as such is not an independent source of knowledge. This is the reason why its mention as a source of knowledge is generally omitted.

10 Q. *What is Perception? What is inference? How are they related to each other logically? Give examples "That tree is a mango tree, it will be loaded with fruits in June" Explain the elements of perception and inference involved in the statement* (*I A.*, 10) *The sources of knowledge are said to be Perception, Inference, and Authority. Explain clearly the nature of each, showing the difference between them by means of examples. With which of them is Logic mainly concerned?* (*I A*, *13*).

A. In the above example, the element 'that tree' is a fact of *perception*, both *immediate* and *mediate*. Immediately I perceive only certain colours, certain form, and the like. But the distance of the tree from me, its solidity, etc., I perceive mediately. That it is a mango tree is a fact of *mediate perception* (involving implicit inference), for I judge it to be a mango tree on the ground of its likeness to other trees which are known to be mango trees. That it will be loaded with fruits in

June is obviously a fact of *inference*, I reason thus :—Mango trees fructify in June, that is a mango tree, therefore, it wil fructify in June.

Logic is mainly concerned with *inference* It may be asked, why *mainly*, and not *solely* ? The reason is that Logic is concerned with many other processes and products, *e g*, terms, propositions, definition, division, classification, observation, experiment, etc But it deals with them only as auxiliary to inference Logic is thus mainly concerned with inference, and incidentally with these subsidiary processes and products

(For the rest see Q 7)

11. Q. *Define the province of Logic in relation to truth and knowledge* (*B A*)

A. In relation to Knowledge :—Logic is essentially concerned with inferential, and incidentally with perceptual knowledge (Explain and illustrate this).

In relation to Truth :—Inductive Logic is concerned with material, and Deductive Logic with formal truth (Explain and illustrate this).

CHAPTER II

INDUCTION AND INDUCTIVE PROCEDURE.

Processes Simulating Induction

12 Q. *What is Generalisation? How will you distinguish between conception and Induction? How are they related?*

A Generalisation is the process of arriving at a general truth on the evidence of particular facts. The general truth, thus arrived at, may be either a general *idea*, called *concept* or *notion*, *e.g.*, man, table, or a general *Judgment*, *e g*, man is mortal. Thus there are two classes of generalisation, *viz*, *conception* and *induction* Conception is the process of generalising a *single property*, *e g*, rationality, or a group of properties, *e g*, rationality and animality, viewed as a unity Thus when by comparing together several individual men, such as Ram, Jadu, Kali, Hari, and a few others, I find two properties common to them all, *viz* animality and rationality, I generalise these two properties over all similar individuals, and form the concept *humanity* Induction, on the other hand, is the process of generalising the *conjunction* of two properties, *e g*, humanity and mortality. Here also I reach the general proposition by comparing and examining several particular cases of mortality of men, and extending the conjunction of the two properties humanity and rationality, found true in these several cases, to all similar cases.

Thus we see that inspite of their similarity conception and induction are radically distinct, the former being the generalisation of one or more ideas or terms, and the latter, of the conjunction of ideas or terms, that is to say, of a judgment or a proposition We should observe here that although induction is distinct from conception, it involves a concept. The induction 'All men are mortal', for example, involves the concept *man*.

[For the processes of forming concepts, see my Deductive Logic, Q. 4]

√ ⁂ **13 Q.** *What is an Induction? What are the characteris-*

ties of a valid induction? Explain and illustrate them fully. (I A, 18)

A An induction is a process of *inference* by which we establish a *general proposition* from particular *observed* facts, in reliance upon the *uniformity of nature*. When, for example, from *some* cases of the mortality of men I infer that *all* men are mortal, I am said to make an induction. The particular facts constituting the materials of induction are supplied by observation and experiment, and the inference from *some* to *all* is drawn on the strength of the uniformity of nature Hence the marks of induction are :—

✓ (*a*) It is an *inference*, for in it we pass from the known to the unknown,—from the observed to the unobserved—from the present to the past, distant, and future—from *here* and *now* to *everywhere* and *always*

(*b*) Induction establishes a *proposition*, as distinguished from a notion. "A notion", as Professor Mitra says, "involves but a single idea or quality, while an inductive proposition expresses a connexion between two notions or terms. Sometimes, no doubt, a notion may be complex, involving a plurality of ideas or qualities, e g., man, matter, book , and in such notions the ideas or qualities, are evidently found connected But there is a difference even between such a complex notion and induction In a complex notion the connexion is tacitly assumed, whereas in induction the connexion is open to question, and has thus to be proved "

(*c*) The inference involved in induction is from the *less general to the more general*, that is to say, the conclusion is *more general* than the premisses In induction there must always be a hazardous leap into the unknown—a passage from *some* to *all* From this it follows that if after examining every tree of a garden I say that all the trees of the garden are loaded with fruits, I do not make an induction ; for in such a case the conclusion is not more general than, but as general as, the premisses In this respect induction is to be distinguished from deduction, which is a passage from *all* to *some*, as also from inference from analogy, which is a passage from *some* to *some*.

(*d*) Induction proposes to establish *material truth*. Its premisses are, therefore, based upon *observation* and *experiment* Induction is not satisfied with the formal consistency of thoughts, but goes beyond so as to see if our premisses and conclusions harmonise with actual facts or not Hence it must necessarily depend upon observation and experiment for its materials

(*e*) Induction is drawn in reliance upon the uniformity of nature. In induction I pass from *some* cases to *all* cases. Having, for example, observed that Ram, Jadu, Kali, Hari, Mati, and many others have died, I infer that *all* men are mortal How can I infer that *all* men are mortal, seeing that I have observed only a few cases? I can not do so unless nature is uniform, *i e.*, unless similar things happen under similar circumstances

N B—It should be noted that the term *induction* is also used as the result of an inductive process, as distinguished from the process itself. All general propositions arrived at by induction are also called inductions.

13 A. Q *Determine the character of inference, and show how it is illustrated in induction* (*I. A.*, 17).

A (See questions 7 and 13)

14 Q *What is the chief problem of Induction?*

A Induction is a generalisation from particular facts, that is, its function it is to establish laws on the ground of particular facts Laws are of three kinds *viz*, (a) laws of equality or inequality, *e g.*, three angles of a triangle = 2 right angles These laws are treated of in Mathematics; (b) laws of co-existence, *e. g*, All men are mortal, *i.e*, in all cases humanity co exists with mortality; and (c) laws of succession including the laws of causation Logic is concerned with the latter two kinds of laws But as the laws of cause and effect are by far the more important, Logic is chiefly concerned with them. Hence the chief problem of induction is to indicate the ways in which causal connexion is to be established between antecedents and consequents.

∴ 15 Q *Analyse the inductive procedure, that is, indicate the steps involved in determining the causal connexion.*

A. The question can be best answered by taking a concrete example. Suppose, I am to ascertain the cause of malaria In the following way we should proceed:—

(1) I must have to *observe* several instances of malaria But a rough sort of observation, that is, the observation of

the circumstances as a whole, will not do I must have to *analyse* the circumstances in each case, that is to say, I must have to observe distinctly the separate accompaniments of malaria in each case The reason is obvious. For, if I do not mark the accompanying phenomena separately, it will not be possible for me to say which one of them is the cause of malaria. This fact of separating each phenomenon from the rest is called *isolation* of *phenomena*

2 The next stage is that of *Framing* a *Hypothesis*. Suppose, in course of my investigation, while I happen to be in a particular village, the people describe to me their bitter experience of mosquitoes This leads me to suspect that mosquitoes *might be* the cause of malaria Accordingly, I frame the hypothesis that mosquitoes are the cause of malaria.

3. The next stage is that of the *Elimination* of irrelevant phenomena by *varying the circumstances* I have now framed the hypothesis regarding the probable cause, *viz* mosquitoes Suppose, in order to prove the hypothesis, that is, to determine whether mosquitoes are the real cause or not, I visit several affected places where I find not only mosquitoes, but also two other phenomena, *viz* dirty habits and drinking habits of the people Under the circumstances, I can not say which is the cause of malaria , it may be mosquitoes, or it may be the dirty or the drinking habits of the people—any one of these three. Unless I can leave out (eliminate) these two latter phenomena, I can not be sure of the true cause But I can eliminate them, *i e*, leave them out by varying (changing) the circumstances Suppose then, I *vary* the circumstances, and go to a place where men are neat and clean (*i e*, the phenomenon of dirty habits eliminated), and next I go to a place where men are of sober habits (*i. e*, drinking habits eliminated). But in both the places I find malaria Hence I reason thus — Since when drinking and dirty habits are eliminated, malaria is not eliminated, none of them can be the cause of malaria. And because mosquitoes are present in all the instances, therefore they are the cause Thus we see that the elimination of phenomena by varying the circumstances is essentially necessary to determine the causal relation.

4 The last stage is that of generalisation. When the conjunction of mosquitoes and malaria is in this way observed in a number of cases, I generalise the conjunction over all

similar cases, and hold that in *all* cases mosquitoes are the cause of malaria

N B We find then that irrelevant phenomena must be eliminated in order to determine the causal relation Here arises an important question :—In which ways, *i e*, according to which *methods*, are we to eliminate these phenomena? Random ways of eliminating them will not do. There must be certain methods which we are to follow. And these are the five Experimental Methods of Mill (called also the Methods of Elimination, to be discussed in Chap VI.)

⁂ 16 Q *What is meant by Varying the circumstances in scientific investigation? What is the use of the process? Give illustration to show its use (I A, 12) Explain :—Varying the circumstances, inductive elimination (I. A, 15) Is elimination the essence of Induction? Fully discuss the question What exactly has Elimination to do with the proof of an hypothesis? (I A, 18) What do you understand by varying the circumstances? (I A, 19) Clearly explain what is meant by the method of varying the circumstances, and show how it helps inductive investigation. Is the method connected in any way with Elimination? (I, A, 21)*

A. [See Q 15]

⁂ 17 Q *Explain and exemplify the process which Bacon called Inference from Simple Enumeration Explain in what its inferiority consists, and how it differs from scientific induction. (I A, 10) Exhibit the character of scientific induction How does it differ from Induction by Simple Enumeration? (I A., 16) What do you understand by induction by Simple Enumeration? (I A, 19). What do you understand by Induction by Simple Enumeration? How is it related to scientific induction? (I A, 21)*

A Inference from Simple Enumeration (Induction per Simple Enumeration) is a generalisation based on uncontradicted experience When, for example, all the crows I have observed are found to be black, and no instance is found to the contrary, *i e.*, no crow is found to be not-black, I conclude that all crows are black. It is obvious that such an induction is precarious, for a single contrary instance will falsify it. Indeed, the induction that all crows are black has been falsified by the discovery of white crows in Australia The value of such an induction is, therefore, very small The greater the number of observed instances, the greater is the probability of such an induction. But it can never reach certainty, nor even a high degree of probability.

Scientific induction is that which is based upon the Methods of Elimination. In other words, it is an induction which establishes causal connection by *eliminating* irrelevant phenomena Now, because in a scientific induction the irrelevant antecedents, which may be suspected to be causally connected with a given effect, are eliminated, it is proved that no one of them can be the cause of the given effect, the invariable antecedent being thus proved to be the cause Induction by Simple Enumeration, on the other hand, is not based on the Methods of Elimination (Experimental Methods). There is no varying the circumstances, no elimination of irrelevant phenomena Hence its conclusion is much less certain than that of scientific induction Scientific induction can establish the laws of causation, but it can establish only the laws of co-existence, *i.e.*, only empirical laws.

✓ ⁂ **18 Q** *Distinguish perfect induction from imperfect induction* (*I. A.*, 14) *Distinguish between perfect and imperfect Induction* (*I A* 17, 18), *and estimate the importance of the distinction* (*I A.*, 17) *Distinguish between perfect and imperfect induction Which of them constitutes induction proper, and why?* (*I A* 21)

A An induction is called perfect, when it is established after *all* the particular cases have been examined, and it is called imperfect, when it is established only after *some* cases have been examined. Thus, when I establish the general proposition, *viz*, that all the members of the present Bengal Legislative Council are above thirty, after having observed each and all of them, it is said to be perfect induction Or, when I state that all the continents have large rivers after having examined Asia, Europe, Africa, America, and Australia, or state that all the apostles were Jews after having examined Paul, Peter, and every other apostle, perfect induction is illustrated On the other hand, when I establish the general proposition that all animals are mortal, after having examined only some cases of mortality, the induction is said to be imperfect

This distinction was drawn by the scholastic logicians of the middle ages But now the distinction is quite unimportant, for according to the modern conception of induction, perfect induction is no induction at all, because there is no element of inference in it. There is no passage from the known to the unknown, because the conclusion states nothing new, but is only an epitome of the premisses. There is no generalisation involved in it—no jump from the observed to the unobserved—no hazardous leap into the dark. It is only a summation of particular observed facts Mill calls it a *verbal transformation.* What was called imperfect induction is what the modern logicians call induction.

N. B—The reason why it is called perfect induction seems to be that the conclusion in so-called imperfect induction is more or less uncertain, because only a few cases are examined. It may be noted here that some modern logicians use the term perfect induction in the sense of scientific induction

19 Q *Are the proofs of Geometry inductive or deductive? You draw an isosceles triangle on a board, and prove that its basal angles are equal, and then draw the conclusion that all isosceles triangles have their basal angles equal Explain the logical character of the conclusion* (*I. A.*, 10)

A Some logicians regard the proofs of Euclid as being inductive, on the ground that in such a proof we reason from *some* to *all* Thus, having proved the equality of basal angles in a particular isosceles triangle drawn on a board, I conclude that such equality holds good in *all* similar triangles. A slight reflexion will, however, show that this reasoning widely differs from induction In induction from a single instance I cannot draw a conclusion, but here from a single case I draw a universal conclusion In induction, the greater the number of instances observed, the greater is the probability: but here the number of instances serves no purpose, one instance being quite enough Lastly, induction cannot give us absolute certainty, but only a very high degree of probability: whereas the conclusion of a geometrical demonstration is certain beyond all question. The fact is that the conclusions of Geometry are *deduced* from definitions, axioms and previously established propositions:—a diagram is drawn only to help the mental process of reasoning.

N B. To this form of reasoning Mill gives the name of Induction by *parity of reasoning*, because the demonstration made with reference to a particular diagram is believed to hold good in all similar cases (parity means similarity). But induction by parity of reasoning is not a separate form of reasoning, but a *deductive* form of reasoning

20 Q *What is a mathematical Induction? Exhibit the logical method involved in a mathematical induction, e g,*

$$1+2+3+4 \quad . + n = \frac{n(n+1)}{2} \quad \text{(B A H, 07)}$$

A When a mathematician observes that

$$1+2=\frac{2(2+1)}{2},\ 1+2+3=\frac{3(3+1)}{2},\ 1+2+3+4=\frac{4(4+1)}{2},$$

and so on, for a sufficient number of times, he concludes that

$$1+2+3 \quad .. + n = \frac{n(n+1)}{2}$$

This form of generalisation, *i e*, the generalisation of a series after having observed a sufficient number of instances of the series, is called a mathematical induction

(There can be no doubt that this is an induction, for the conclusion is *inferred* from particular instances, and it is *more general* than the premises A single instances is not enough here (as in geometrical proof) to establish the general conclusion, a sufficiently large number of instances is necessary for the purpose Still it cannot be said to be a scientific induction, for it is not based upon the experimental methods In fact, it is an induction per simple enumeration, based upon universal agreement (uncontradicted experience), partaking of the nature of the ultimate laws of nature)

21 Q *What is a Colligation of facts? Distinguish between Colligation and induction*

A Colligation literally means *binding together.* Colligation of facts may be defined as the "mental operation which enables us to bring a number of actually observed phenomena under a general description, or which enables us to sum up a number of details in a single proposition" (Killick, after Mill) Facts are said to be colligated when they are bound together by a suitable conception Thus when I observe that each boy of a particular class is intelligent, I conclude that all the boys of the class are intelligent This is perfect induction, and here I connect together all the boys of the class by the notion of intelligence Hence perfect induction is colligation. Again, when I form the concept *man*, I connect together the individuals of a species by the notion *humanity* Hence conception is also colligation Thirdly, when from some cases of mortality, I infer that all creatures are mortal, I bind together the individual creatures by the notion of mortality And this is induction Hence induction is also colligation Then again, when Kepler, after having observed different places occupied by the planet Mars at different times, joined together these places by the conception of an ellipse, and held that the orbit of the planet Mars is elliptical, he is said to have colligated these different places In like manner, classification, definition, and description are cases of colligation of facts, for in these also we bind together facts by appropriate notions.

Whewell identifies colligation with induction But from what we have said above it is quite clear that colligation is something more than induction, as it includes many other processes, *e g*, conception. In most cases of colligation, as we have seen above, there is no real inference involved Hence, Whewell's identification of colligation with induction is based on a misconception of the nature of induction Mill, therefore, rightly remarks that induction is colligation, but colligation is not necessarily induction.

22 Q *Distinguish clearly between complete and incomplete induction* (*I. A*, 18)

A The term 'complete induction' is ambiguous. Bain uses the term complete induction in the sense of what is ordinarily called induction, including both "scientific induction and induction per simple enumeration. 'A complete induction" says Bain, "is a generalisation that shall express what is conjoined everywhere and at all times" Unlike perfect induction it is a leap, an advance from the known to the unknown—from the observed to the unobserved. The term *complete induction* is sometimes used also in a narrower sense, so as to mean only scientific induction, and not induction per simple enumeration The term "incomplete induction' also is vague and ambiguous Some, *e g*, Fowler, use it in the sense of an induction which has not fully satisfied the conditions of one or other of the experimental methods An incomplete induction is the result "of an imperfect fulfilment of one or other of the inductive methods"(Fowler) Others use it in the sense of an inference which involves a subconscious and implicit operation of a universal proposition. This is illustrated when seeing that a number of tigers are carnivorous, I declare that the tiger before me must also be so. Here I cannot say that this new tiger is carnivorous, unless all tigers are carnivorous So my inference is impossible without the aid of the universal proposition And yet I am not conscious of the universal proposition, but pass from particulars to a particular, the universal proposition operating but implicitly. Inference from analogy is of this type

23 Q *State, explain, and illustrate the various kinds of induction, improperly so called Explain clearly in each case why it is not an induction in the proper sense of the word.* (*I.A.*, 11) *What are the different kinds of processes that simulate induction? Exhibit and illustrate each of them, and explain in each case why the process is not real induction* (*I A*, 19)

A The following are the kinds of induction, improperly so called :—

1 Perfect Induction (Verbal Transformation, as Mill calls it)

2 Proofs of Geometry (Inductions by Parity of Reasoning, as Mill calls them)

3. Colligation of facts

The above are also called processes simulating induction, because they look like inductions, but really are not inductions

[As for their explanation, and as for why they are not really inductions, see QQ 18, 19, 21.]

CHAPTER III.

GROUNDS AND CONDITIONS OF INDUCTIVE INFERENCE.

Uniformity of Nature.

24 Q *Distinguish between the form and the matter of reasoning From what sources does thought obtain materials for its reasoning?* (*I A*, 12)

A. Everything has both *form* and *matter*. Take, for example, a table A table may be rectangular or circular in form or shape. Again, its matter may consist in wood or stone. So two tables may resemble, or differ from, each other in respect of both form and matter, or in respect of any of them. Similar is the case with reasoning The *form* of reasoning consists in the *process* of drawing the conclusion, *i e.*, the *method* according to which the conclusion is drawn, and the *matter* of reasoning consists in the *materials* or *terms* constituting the premisses. Two arguments may differ from each other in respect of both form and matter, or in respect of one of them For example, the syllogism "All men are mortal, Indians are men, therefore Indians are mortal," differs from the syllogism "No beasts are rational, all cows are beasts, therefore no cows are rational" both in form and matter. They differ in form, because one is in Barbara, and the other in Celarent, and they differ in matter, because the terms constituting the premisses of the one are different from those constituting the premisses of the other (There are three fundamental forms of reasoning, *viz*, inductive, deductive, and analogical. In the inductive form the process of reasoning is from *some* to *all*, in the deductive form, from *all to some*; and in the analogical form, from *some* to *some*.

Observation and experiment are the sources from which we derive materials for inductive and analogical reasoning. As for the materials (premisses) of the syllogism, the universal premiss is either a necessary truth, or is supplied by a previous induction, and the particular premiss is supplied by observation and experiment. (Give examples)

25 Q *State the ultimate grounds of induction* (B A, 07) *Explain and illustrate the basis of the argument from the known to the unknown* (B A, 01) *Investigate the grounds and conditions of inductive inference* (I A., 17. *State and explain the grounds of inductive inference* (I.A, 18)

A Grounds of Induction The expression 'grounds of induction' is used in a twofold sense. In the first place, it means the principles or laws underlying the *form* or *process* of inductive reasoning—the principles upon which the process of inductive inference is based 'These are, therefore, called the *formal grounds.* Secondly, it means the sources from which the *materials* of induction are derived These are, therefore, called the *material grounds* 'The uniformity of nature' and 'the laws of causation' are the formal grounds of induction, and 'observation' and 'experiment' are its material grounds Let us consider these one by one —

I Formal Grounds of Induction

(A) Uniformity of Nature Before understanding how the uniformity of nature constitutes the formal ground of induction, we should understand what the expression means The uniformity of nature, being an ultimate fact, is strictly indefinable It has been variously expressed thus —'Nature repeats itself', 'the future resembles the past', 'whatever had been will be', 'the absent is like the present', 'the universe is governed by laws', and so forth Its precise meaning is that under similar circumstances nature behaves similarly, that is to say, if the same or similar conditions be repeated, the same or similar phenomena will recur If water quenched thirst in the past, it will always quench thirst, if fire burnt in the past, it will always burn, if oxygen supported combustion in the past, it will always support combustion, and so on It may be asked, why should it be so? Why, for example, should water be always quenching thirst, because it did so in the past? The realistic philosophers answer this question by saying that all waters are identical in essence, and that this essence, being identical, manifests itself in the same way in all cases This essence is called the ground, and the manifestation is called the *consequent* So we see that the realists explain the uniform behaviour of nature by the essential identity of the same class of objects,—by the principle of the ground and consequent But the empiricists have no explanation to offer. They simply say that similar events will take place under similar circumstances But a question may be raised here, is nature really uniform? How can you say so in view of her thousand and one whimsical behaviours? How, for example, will you reconcile her apparent irregularities, such as earthquakes and cyclones, with her uniformity? In answer to this we may say that earthquakes, cyclones, etc., are no exceptions to the rule of uniformity, rightly understood. For whenever the conditions under which earthquakes, etc., happened in the past are repeated, these will invariably occur. We may as well argue, because Indians are dark-complexioned and Englishmen are fair-complexioned, therefore nature is not uniform, or because to day it is raining, but last year on this date it did not rain, therefore nature is not uniform Such arguments, if adduced by any, are evidently based on the misconception of the nature of the uniformity of nature. Had the climatic conditions of India obtained in England, surely Englishmen would have been as dark complexioned as Indians. So we see that the caprices and irregularities of nature are but seeming, and not real, and that nature at bottom is uniform in operations

We next pass on to consider how the uniformity of nature constitutes a formal ground of induction. Suppose I observed several cases where oxygen supported combustion. How can I jump from these few cases to the universal conclusion that oxygen supports combustion in *all* cases? What is the justification of this leap from *some* to *all*—from the known to the unknown—from the observed to the unobserved? I can do so only on the assumption that oxygen will behave in the same way in future as it was found to behave in the past, that is to say, that nature is uniform so far as this case is concerned. The uniformity of nature is thus the ultimate assumption, the ultimate ground of all inductive inferences In fact every inductive inference is ultimately speaking, a syllogism with a uniformity of nature as the major premiss For example, when from some cases of human mortality it is inferred that all men are mortal, the inductive reasoning may be thrown into the syllogistic form thus:—Whatever is true of Ram, Jadu, Kali, Hari, and a few others is true in all *similar* cases, *i e.*, in cases of all men (major) : mortality is true of Ram, Jadu, Kali, Hari, and a few others (minor) : therefore, mortality is true in all similar cases, that is to say, all men are mortal (conclus

(B) **Law of Causation** The law of causation states that every phenomenon must have a cause Logic is not conversant with the cause of the universe as a whole, but of finite things and events which have beginnings in time, i e, of *phenomena* The question is how the law of causation forms a ground of induction. We know that the main function of induction is to lay down rules for determining the causes of particular phenomena. Now, if there be no law of causation, that is to say, if there be no knowing that all phenomena are caused, then there is uncertainty as to whether a particular phenomenon has a cause or not, and consequently an attempt to determine its cause may chance to be futile Moreover, we know that causes are determined by the experimental methods, and those methods are the different aspects of causation Hence induction is based on the law of causation.

Thus we see that neither the uniformity of nature nor the law of causation constitutes by itself the formal ground of induction. but both of them taken together. The law of causation, coupled with the uniformity of nature, is that the same cause always produces the same effect

N B.—It should be noted that the empiricist cannot consistently make a separate mention of the law of causation, seeing that it is but a special form of the uniformity of nature

II Material Grounds of Induction :—

(*a*) **Observation.**—The particular cases from which the general conclusion is drawn are supplied by observation Thus when from some cases of the rusting of iron I infer that in all cases iron rusts if exposed to air, I gather the particular instances of rusting from observation.

(*b*) **Experiment** In some cases nature does not present us with suitable instances, from which we are to arrive at a general conclusion In such cases we are to produce them artificially i, e, by means of experiment (for the distinction between observation and experiment see Q 42)

N B—The expressions 'ground of induction' and 'condition of induction' are usually taken as synonymous. Some, however, distinguish between them. In Prof Mitra's book, the following conditions are mentioned—(A) Subjective

CHAPTER IV.

GROUNDS AND CONDITIONS OF INDUCTIVE INFERENCE

(CONTINUED).

CAUSATION.

30 Q *What is the Law of Causation? How may the law be best expressed?* (*I A, 15*).

A Logic is not concerned with the cause of the Universe as a whole, but of a limited portion of it In other words, it is concerned with the cause of a phenomenon, a change, a fact that has a beginning. Killick states the law after Mill thus:—(1) 'Every phenomenon which has beginning must have some cause (2) Given the cause, the effect will invariably follow, provided that counteracting causes do not exist.' The law thus consists of two clauses. The first clause states that nothing can be uncaused, that is to say, that nothing can happen by chance or spontaneously. When, therefore, we say that such and such an event has happened *by chance*, all we mean is that we are ignorant of its cause. The law of causation thus leaves no room for chance It denies that anything can take place spontaneously—that something can arise out of nothing Whenever, for example, a man dies, a house is burnt, or there is a flood, there must be a cause—it cannot happen of itself. The second clause states that the effect follows the cause uniformly It denies 'that events follow one another irregularly, indiscriminately, or capriciously." Under similar circumstances fire will always burn, or a body will always fall, as it did in the past This part of the law of causation is an aspect of the law of uniformity.

The above statement of the law of causation is silent upon the question of the nature of cause, *viz*, whether the essence of cause is force, or will, or anything else Now, in Empirical Logic the term cause is not taken to mean an efficient or a final cause The cause of a phenomenon is also a phenomenon Hence a better and more explicit statement of the law is that made by Bain, which runs thus :—"Every event that happens is definitely and uniformly connected with some prior event or events, which happening, it happens, and which failing it fails."

✓ *.*. 31 Q *What are the marks of the cause of an event, when it is capable of being exactly ascertained? Explain and illustrate them (I A, 16) Determine the character of the cause (I A, 21) Examine in detail the statement that cause is the immediate, invariable, and unconditional antecedent of an effect.* (I A, 20)

A The cause of a phenomenon may be defined as the group of antecedents which occurring, the given phenomenon follows, invariably and unconditionally. Let us analyse this definition so as to ascertain the marks of a cause .—

(1) The cause is *antecedent* to the effect, that is to say, the cause is a phenomenon that precedes the effect, which in relation to the cause is called *consequent* But this is a disputed point It has been said by some that since the cause implies an effect, the cause cannot exist until the effect occurs, so that the cause and effect are simultaneous "But this is a blunder, for whilst the word *cause* implies effect, it also implies futurity of the effect, and effect implies the relative priority of the cause," (C Read) Again, when we say that the sun is the cause of light, or that gravitation is the cause of the fall of bodies, the cause is synchronous with the effect, for there can be no light or no fall of bodies if the sun ceases to rise or gravitation ceases to exist In answer to this it is said that the cause in such a case is 'made up of moments or minute factors,' and that the effect is also made up of corresponding moments, and that each moment of cause is antecedent to the corresponding moment of the effect, so that although the whole cause may not precede the whole effect, each fraction of the cause precedes the corresponding fraction of the effect. We must not, however, draw a sharp line of demarkation between the cause and the effect seeing that the operations of nature are continuous

(2) The cause consists of *invariable* antecedents It goes without saying that every antecedent cannot be regarded as cause Suppose I move my hand, and the next moment mango falls from a tree Here although the movement of hand precedes the fall of the mango, it cannot be held as it

cause. If A sometimes precedes B, and sometimes not, then it cannot be considered to be the cause of B. The cause must precede the effect in all cases without fail.

(3) The cause is the *unconditional* set of antecedents. Had every invariable antecedent been the cause, then day would have been regarded as the cause or effect of night, or the flash of the gun would have been regarded as the cause of its report But no one entertains such a view. From this it follows that the cause is something more than a bare invariable antecedent In fact, the cause is, as Mill says, the unconditional group of antecedents, that is to say, the cause is the assemblage of antecedent events which can give rise to the effect without depending on further conditions This is the reason why day cannot be held as the cause or effect of night, for day's preceding or succeeding night depends upon the further condition of the rotation of the earth round its axis.

(4) The cause is the *immediate* set of antecedents An antecedent which is very remotely connected with an event is to be excluded from its cause If we are at all to honour such a distantly connected antecedent with the title of cause, we should call it a *remote* cause (for the meaning of the term 'remote cause' see the next question) It should be noted that *immediacy* follows from *unconditionalness*; for if B succeeds A without depending upon further conditions, it follows that B succeeds A immediately It should, however, be observed that the term *immediate* must not be construed too strictly, for there may be sometimes a noticeable interval of time between a cause and an effect

Thus we see that the marks of cause are (1) antecedence, (2) invariability, (3) unconditionalness, and (4) immediacy. These are called the *qualitative* marks of a cause. To these another mark is added by the upholders of the doctrine of conservation of energy, *viz.*, (5) the equality of cause and effect This is called the *quantitative* mark of a cause For example, two molecules of hydrogen and one molecule of oxygen, combined together, give rise to an equivalent amount of water.

** 32 Q *Expound the scientific conception of cause.* (*B A*, *93*). *Analyse the scientific conception of a cause*, (*B*, *A*, *07*) *What is meant by the cause of an event? Explain the difference between the cause and condition of an event, and* *distinguish between the proximate and remote causes Illustrate your meaning by examples. A man is crossing a river in a small boat, a sudden squall of wind comes on, the boat founders and the man is drowned What do you consider to be the cause and conditions of his death ? (I A, 13) What do you consider to be the difference between cause and condition ? Give examples 'If a workman carrying a burden falls from a ladder and is killed, what do you consider to be the cause and conditions of his death ? A distinction may be made between cause from 'the scientific and cause from the merely practical point of view In the above case what may be regarded as cause from the merely practical point of view ? (I A, 11) Distinguish, between the scientific and the popular view of causes (I A, 14) Define precisely what is meant by cause of an event How is a cause distinguished from condition ? (I A, 17) Explain cause and condition (I A, 15). What is a cause ? What is a condition ? What is the relation of the latter to the former (I A, 18)* [illegible]

[illegible] of an event is its indispensable antecedent [illegible]

A. The scientific Conception of Cause [illegible]

The cause of an event is its invariable, unconditional group of antecedents Each of these antecedents is called *condition* ("A condition may briefly be defined as that which exercises some influence on the effect the influence may be in the form of either production, prevention, or modification Anything which helps, destroys, or retards an effect may be viewed as a condition" (Mitra) Conditions may thus be either positive or negative The positive conditions are those which help and the negative conditions are those which thwart the production of the effect In other words, the positive conditions are those which being *present*, and the negative conditions are those which being *absent*, help the production of the effect, that is to say, if the positive conditions be *absent*, the effect will not be produced, and if the negative conditions be *present*, the effect will not be produced A condition is thus a part of the cause, and from the strictly scientific point of view, a cause is the sum total of conditions, both positive and negative, In the first example given above, the man's death is due to the following conditions, *viz.*, (*a*) his crossing a river, (*b*) his doing so in a small boat, (*c*) the sudden squall of wind, (*d*) gravitation, (*e*) the suffocating property of water, and the like. These are the positive conditions, because they being present, the effect is produced. But then if a boat came to his rescue, or if he were a skilful swimmer, he would not have died. Hence the absence of a rescuing boat and his inability to swim are the negative conditions. The aggregate of these conditions, positive and negative, constitutes the cause. [The student may, on the line just indicated, analyse the second example]

We have said above that from the scientific point of view, the cause is the totality of conditions, both positive and negative Now we know that the various parts of the universe are interrelated, so that if we strictly insist upon including all the conditions, then it comes to this that the whole universe is involved in the production of each effect. We must, therefore, include only the proximate conditions and exclude the remote ones Of the proximate conditions again those are generally omitted which are too obvious, and whose mention is, therefore, superfluous or pedantic. For example, in mentioning the conditions of the fall of a man from height the element of gravitation is generally omitted, as being too obvious.

Proximate and Remote Causes—A proximate cause is that upon which the effect directly follows, and a remote cause is that between which and the effect there intervene one or more causal links, that is, which is only distantly connected with the effect. In the above example, the man's being in a small boat is a proximate cause, but the making of the boat is a remote cause The scarcity of rice is the proximate cause of a famine, and the rats which destroy crops are the remote cause Clouds are the proximate cause of rain, and the evaporation of water from the surfaces of the river, the sea, etc, is the remote cause. It should be observed that what is called a cause here is really a condition. Strictly speaking, a proximate cause is the sum-total of proximate conditions, and a remote cause is the sum-total of remote conditions A proximate cause is otherwise called an *immediate or direct* cause, and a remote cause, a *mediate or indirect* cause

Scientific and Popular Views of Causation :—

A distinction is drawn between the scientific and the popular view of a cause. In popular language one of the antecedents is usually taken to be the *cause*, the remaining antecedents being regarded as the *conditions* of the effect The question is which antecedent is generally singled out as the cause Here there is no unanimity, for different people select different antecedents Some will select that antecedent which comes last, and upon which the effect immediately follows. Some will select that antecedent which is peculiar, and whose share in the production of the effect is striking And some will select that antecedent which is interesting to them for some reason or other Thus in the above example, some will say that his being in a small boat in a river is the cause of his death Others will say that the rising of the squall of wind is the cause Others again will say that his inability to swim is the cause of his death, thus regarding even a *negative* condition to be the cause

Cause from the practical standpoint :—

From the practical standpoint, that one of the antecedents is singled out as the cause which serves some practical purpose In the above example, a commercial man will regard the use of a small boat to be the cause, for that will give him a practical lesson not to use such a boat in a river From this it is obvious that the practical standpoint is an aspect of the popular view But usually the practical view of causation is regarded as the same as the popular view

⁂ 33 Q *What is an intermixture of effects? Give examples* (*I A*, 11) *What is meant by the composition of the causes?* (*I A*, 09) *Explain :—Intermixture of effects* (*I A*, 15)

✓ A When several causes, combined together, give rise to a complex effect, the effect is said to be an intermixed effect and such a cause is said to be a case of intermixture of effects. Thus when nitorgen and oxygen, combined together, give rise to nitric oxide, it is a case of intermixture of effects In an intermixture of effects the individual effects of the constituent causes are blended together so as to lose their individuality An intermixture of effects is of two kinds, *viz* *homogeneous* and *heteropathic*. When the resulting effect is of the same kind with the component causes, it is a cause of homogeneous intermixture This is illustrated in Mechanics Thus when a body is pulled by two men, the resulting motion is of the same kind with the motions of the men When, on the other hand, the resulting effect is of a different kind from the component causes, it is a case of heteropathic intermixture . This is illustrated in chemical combinations Thus when oxygen and hydrogen form water, the latter is of a different kind from the former. It should be observed that the joint effect is never wholly heteropathic The *weight* of a combination of two elements, *e.g*, iodine and potassium, is, for instance, the sum of the weights of the separate elements ; so that in the case of a heteropathic intermixture, too, the intermixed effect is to a certain extent of the same kind with the component causes

In all cases of intermixture of effects the causes require to be combined. Such a combination of the causes is called *composition of causes*

N. B. Mill uses the term *composition of causes* in the case of homogeneous intermixture, and calls the intermixed effect in such a case a *compound effect* In the case of heteropathic intermixture he uses the term *combination of causes*, and calls the intermixed effect in such a case a *heteropathic effect* But generally the term 'composition of causes' is used to cover both the cases.

34 Q. *What is a Progressive Effect?*

A A progressive effect is a complex effect arising from the accumulated influence of a constant cause A cause may be either temporary or permanent If temporary, it will vanish after producing its effect. But if permanent, then it may go on producing the effect every moment. Take the case of the rusting of iron, when exposed to moist air. Moist air does not vanish after producing its effect, *viz*, rusting, but continues to produce rusting all along This accumulated effect due to the action of a constant cause is called a *progressive effect.* When a body falls, it occupies successive positions downward, say X, Y, and Z Its motion from X to Y is caused by gravity. Now. if gravity ceased after having produced this motion, the motion would continue. But gravity, instead of vanishing, remains fixed. and is every moment acting upon the body. Hence the result is that its motion from Y to Z is more rapid than its motion from X to Y.

There are two kinds of progressive effects :—(*a*) When the constant cause does not vary. In the above instances the earth and moist air remain the same, and (*b*) when the constant cause itself varies Take the case of heat in summer. If the sun remained fixed in its position, it would produce a progressive effect by its constant action. But the sun changes its position, and draws nearer to the vertical position Thus it not only constantly produces its effect, but produces it more and more every moment Hence the action of the constant cause is twofold in this case on account of its own change.

**35 Q. *Explain the meaning of Energy and Conservation of Energy, and show the bearing of the theory on the nature of causality.* (*I. A , 09*)

A Doctrine of Conservation of Energy—Energy means the capacity of a body to move. It is of two forms, *viz*, *potential* and *kinetic* Potential energy is the force lying dormant, as the energy of our body when at rest Kinetic energy is the force manifested in motion, as when we move our limbs When our body is at rest, it is not to be understood that it has no power to move itself, only that it does not exercise the power for the time being It is then said to have potential energy. And when it exercises the power so as to set itself in motion, its energy is said to be kinetic. In like manner, when a steamer is in motion the energy of its engine is kinetic, and while it stops at an intermediate station, its energy remains potential.

The doctrine of the conservation of energy holds (*a*) that the total amount of energy in the universe is constant, and (*b*) that when one kind of energy, *e g*, electrical, passes into another, *e g* molar, as in the motion of a tramcar, we get an equivalent amount, nothing being gained or lost in the passage The law of conservation thus consists of two parts In the first place, it states that the energy of the universe is a fixed-quantity, admitting neither of increase nor of decrease. In the second place, it states that the different kinds of energy are mutually transformable, and that in such transformation of one into another there is not even an atom of gain or loss We know that there are various kinds of energy such as mechanical (molar) force, electricity, nerve force, and light When any one of these forces is converted into another, we get just an equivalent amount

The Conservation of Energy has a twofold bearing upon Causation :—

First, it changes the ordinary view of causation as mere succession According to this doctrine, the effect is not a mere successor of the cause, but it is the *cause* transformed—the matter and energy of the cause, e g. oxygen and hydrogen, are redistributed in the matter and energy of the effect e g water It thus changes that view of causation according to which the cause and the effect are two separate phenomena, the latter succeeding the former, and substitutes the view according to which the cause and the effect are the different forms of the same energy, the cause being the energy *before* its transformation, and the effect *after* its transformation.

Secondly, it proves the equality of the cause and the effect. Since in the transformation of a cause into the effect nothing is lost or gained, the effect is necessarily equal to the cause It may be objected that we often see disproportion between a cause and an effect. When, for example, a small spark of flame sets a whole house on fire, or an insignificant revolutionary pamphlet throws an empire into revolution, the effect is apparently too big for the cause We may meet this objection by distinguishing between what are called an agent and a patient. We can thus see that it is owing to our mistaking the agent for the sole cause that we see disproportion between the cause and the effect. An agent (or moving power) is the exciting cause, and a patient (or collocation of materials) is the material (supposed to be Passive) upon which the agent operates so as to produce an effect. Thus when a lighted match stick is applied to a quantity of gunpowder, the former is the agent and the latter is the patient. But the distinction is not a valid one, as Mill observes. For the patient is not really passive ; an amount of force is contained in it, though potentially A tiny match-stick is not the sole cause of a huge explosion , it is only an exciting cause, serving merely to rouse the mighty force lying dormant in the powder It is only when we regard a moving power, e. g. the match stick in the above example, to be the sole cause that we find disproportion between the cause and the effect, and are apt to exclaim with the poet—"What great events from trivial causes spring " But when we take a correct view of the matter and see that the agent is only a small part of the cause, and that the far greater part of the cause lies in the collocation, we find no disproportion between the cause and the effect Thus we see that causation, in its quantitative aspect, is based on the law of the conservation of energy

✓ 36 Q *What do you mean by a tendency, and a counteracting cause ?*

A Tendency is *the unsuccessful striving* of force to pass into motion The force cannot pass into motion, either because the force applied is not sufficient for the purpose, or because it is counteracted by an opposite force.

A counteracting cause is that which tends to neutralise the effect of another cause When a rope is pulled in opposite directions by two forces, each force is a counteracting cause in relation to the other.

37 Q *What do you understand by the mutuality (reciprocity) of cause and effect ?* (I A, 17) *Explain and illustrate mutuality of cause and effect* (*I A*, 21)

A Sometimes, especially in complex human affairs, it is the case that while A causes B, B also causes A There is, therefore, a relation of mutual causation between A and B Ignorance causes poverty, and proverty in its turn causes ignorance Hunger is the cause of revolution, which again is the cause of hunger It is very often the case that A trusts, loves, or hates B, because, B trusts, loves or hates A, and *vice versa* This fact of the action and reaction of cause and effect is called mutuality or reciprocity of cause and effect

38 Q *What do you mean by the diversity of effects ?*

A The diversity of effects is the reverse of the intermixture of effects In the latter, several causes, combined together, give rise to a single complex effect, whereas in the former a single cause if supposed to give rise to a number of distinct effects War, for example, gives rise to death, famine, epidemic diseases, bankruptcy etc, fire gives light, evaporates water, melts substances, and so forth These several effects produced by a single cause are called *joint effects* or *co effects*

39 Q *Explain and illustrate the plurality of causes* (*B A H*, 07) *What do you understand by the plurality of causes ? Illustrate your answer by examples* (*I A*, 17). *Is the doctrine of the plurality of causes tenable ? Explain what is meant by* (*a*) *plurality of causes,* (*b*) *composition of causes, illustrating each answer by one example.* (*I A*, 20).

A The plurality of causes (or the viciriousness of causes, as it is called by Fowler) means that the same effect may be due to each of a number of several causes *acting-separately* Thus death may be caused by hanging, drowning, cholera, etc., light may be caused by fire, the sun, etc, and so forth. The plurality of causes is to be distinguished from the composition of causes, where several causes produce an effect *conjointly*, and not *separately*

Strictly speaking the doctrine of the plurality of causes is untenable, as is evident from the following considerations :—

(1) If we closely look into the effects produced by different causes we shall find that they are not really the same The light produced by the sun is different from the light produced by fire. They differ in colour and other properties. Hence it is not the same effect which is produced by these different causes, but different effects Thus, if we take into account the special features of each effect, that is if we *specialise* the effects, then there is no plurality of causes. (2) Again, the effect is produced not really by distinct causes, but by some property which is common to the different causes. The effect light, though it is apparently produced by different causes, *e g* the sun and fire, is really produced by the vibrations of the molecules of the sun and of the lighted body, showing that light in each case is the effect of the vibrations of the molecules of a body giving rise to ethereal vibrations Thus if we *generalise* the causes, that is, consider the general or common aspect of the different causes, there is no plurality of causes

Hence it is said that the doctrine of the plurality of causes may be exploded either by generalising the causes or by specialising the effects But though, strictly speaking, there is no plurality of causes, yet it is recognised for practical, and even for scientific purposes , for it is not possible, nor is it necessary, to take into account the minute details of each effect, or abstract the common feature of different causes

✓40 Q. *What are the different aspects under which causation may be viewed? Give a concrete example of each,* (*I A*, 15)

A Causation may be viewed under two aspects .—(*a*) Causation viewed scientifically, (*b*) Causation viewed popularly The scientific view may again be either qualitative or quantitative, the latter being based on the law of the conservation of energy

[See Q. 32 and 35]

✓41 Q *State the relation between uniformity of nature and the law of causation.*

A From the empirical standpoint, causation is a form of uniformity—it is that form of uniform succession which is invariable and unconditional. But according to the rationalistic theory, causation is not bare succession, but *production*, that is, the idea of force or power is the essence of causation, And though this power produces its effects uniformly, it is not necessary that it will do so. Hence according to the rationalistic theory, the notion of uniformity is not necessarily involved in causation.

CHAPTER V

GROUNDS AND CONDITIONS OF INDUCTIVE INFERENCE

(CONTINUED).

Observation and Experiment

✓ ⁂ 42 Q *Show, by a careful account of observation and experiment, that the difference is one, not of kind, but of degree,* (*B A*, 04),

A. Observation is careful and regulated perception of phenomena under conditions presented by nature, while experiment is such perception under conditions made by ourselves We are said to *observe* the operations of the heavenly bodies, the states of our own mind, and so forth On the other hand, when we pass an electric current through a quantity of water so as to observe that it is resolved into hydrogen and oxygen, we are said to make an *experiment* Thus the difference between observation and experiment is said to be that in the former we are *passive*, while in the latter, *active* But a slight reflexion will show that observation is not altogether passive, for when we are to observe a particular phenomenon, we are to isolate it from other complex phenomena and keep our attention fixed upon it by an *effort* of mind. Hence the real difference between observation and experiment in this respect is that in experiment we are *more active* than in observation, that is to say, the difference is one of degree only. Again it is said that in observation the conditions are presented by nature, while in experiment they are made by ourselves, that is to say, in the former the conditions are *natural* while in the latter *artificial* But strictly speaking, this is not true, for in observation also we very often alter the circumstances to a certain extent In order, for example, to observe something in a dark room I have to light a candle Here a condition is made by me Again, in order to observe the heavenly bodies we use telescopes. Now the use of a telescope is surely an *artificial* condition, *i e.*, a condition created by

Condition :—(1) "Patience and perseverance in research" Observation, and especially experiment, are often very laborious processes requiring a good deal of patience. No scientist can succeed unless he perseveres in the face of repeated failures. (2) Absence of bias and prejudice Truth cannot be reflected in the mind in its true proportion if it be vitiated by passions and prejudices (3) Concentration of mind. A distracted mind is unfit for any task, far less for scientific investigations (4) Imaginative insight To discover the cause of a phenomenon a hypothesis has to be framed But a hypothesis cannot be framed without imaginative insight. (B) objective Conditions :—(1) Analysis, *i e*, separation of elements, (as for how it is necessary in induction see Q 15) (2) Verification. The hypothesis, which is the preliminary stage of induction, must be verified by an appeal to facts before it can be exalted to the rank of a valid induction or law

26 Q *What precisely do you understand by the principle of uniformity of nature* (*I A*, 09) *Explain and illustrate fully the principle af uniformity of nature What are the fundamental kinds, classes or branches of uniformity found in nature? What is meant by saying that uniformity of nature is the ground of induction? Do you consider cyclones and earthquakes to be consistent with uniformity?* (*I A.*, 12)

A The fundamental kinds of uniformity are enumerated by C. Read as follows :—

1. The fundamental principles of thought, *viz*. the laws of Identity, Contradiction, and Excluded Middle. These are the laws not only of thought, but also of things Had it not been the case, then we could not have understood things (For the meaning of these laws see my Deductive Logic, Q 22)

2 Certain Axioms of Mediate evidence, such as Mathematical Axioms and Aristotle's Dictum.

3 The fixed relations of times and spaces. If the same portion of space or time now increased and now diminished, no experience would be possible "If time really trotted with one man, and galloped with another, if space really swallowed in places, experience could not be compared and science would be impossible" (C. Read)

4. The persistence or conservation of matter and energy (see Q. 34)

5. Causation (see Chapter IV).

6. Certain uniformities of co existence, such as follows :—

(*a*) Geometrical co-existences, *e. g*, in a triangle the equality of sides co-exists with the equality of angles

(*b*) Co-existences among the universal properties of concrete things, *e. g*, gravity co-exists with inertia.

(*c*) "Co-existences due to causation, such as the positions of objects in space at any time. The houses of a town are where they are because they were put there, and they remain in their places as long as no other causes arise strong enough to remove or destroy them. Similarly, the relative positions of trees in a forest or of rocks in geological strata are due to cause" (Read)

(*d*) Co-existences of properties in natural kinds, *e g*, the co existence of the different properties of oxygen, carbon, gold, etc

(*e*) Certain unaccountable co-existences, *e g*, the scarlet flowers are non fragrant, most metals are whitish

(As for the rest of the question, see Q. 25)

27 Q *What does Bain mean by saying that there is not uniformity but there are uniformities?*

A 'Uniformity of nature' is a vague term We do not understand anything definitely when it is said that nature is uniform She must be uniform in certain respects In other word, there are various departments of nature, and in each department there is a uniformity, so that there are various uniformities.

✓ **28 Q** *What do you consider to be the ground or evidence underlying our belief in uniformity? (I A 12).*

A There are mainly three theories regarding the origin of our belief in the uniformity of nature, as in every other axiom, such as the law of causation, the law of the conservation of energy, or the axioms of mathematics :—

1. **The a posteriori or Empirical theory, represented by Hume, Mill, Bain, and others.** According to this theory these ultimate principles are based on Induction per Simple Enumeration Because everywhere we find uniformity, and nowhere we find an instance to the contrary, therefore we believe in uniformity Similar is the case with other axioms, such as the law of causation. This

belief is, however, not a conscious process, but is engendered in us unconsciously in the early days of life. They are based upon uncontradicted experience—upon universal agreement

Criticism :—(*a*) If the ultimate principles are only inductions per simple enumeration, then they are only *probable* and not necessary and universal. But we regard them as necessary and universal. (*b*) Scientific induction is based upon the uniformity of nature and the law of causation. But if the latter are based on induction per simple enumeration, then it follows that scientific induction is based upon induction per simple enumeration and hence becomes as precarious.

2. **The a priori or Intuitional theory, represented by Reid, Kant, and others** According to this theory, the uniformity of nature, as all other axioms, are the intuitions of our mind,—they exist in our mind before all experience,—they are implanted in our nature by God.

Criticism :—(*a*) This view is dogmatic, for it gives no reason for supposing these principles to be innate (*b*) If they are intuitive, then it is reasonably expected that all men should agree with respect to them Why is it then that men differ as to which principles are universal and necessary, and which not? (*c*) The fact that children do not understand these principles, or at least that grown-up people understand them better than children, shows that they are the results of experience

3 **The Evolutional theory, as represented by Spencer.** According to this theory, belief in uniformity, as in other fundamental principles, was originally acquired from experience by our remotest forefathers, and handed down from generation to generation, being strengthened in each generation by fresh experience, until it has become so strong as to require no further experience to confirm it. Therefore, the belief was originally *a posteriori*, *i e.*, acquired ; but now with us it is *priori*, intuitive, or innate. Thus the evolutional theory reconciles the above two theories—the belief *was* acquired, but *is* intuitive,—and hence seems to be the plausible view

N. B,—It should be noted that the question regarding the origin of our belief in uniformity, as in other fundamental principles, is a psychological, and ultimately a metaphysical, one, and as such beyond the scope of Logic,

✓ **29 Q** *'The ground of Induction is itself an induction'. Fully discuss this. How can a conclusion which asserts more than premisses be valid? Fully discuss this question,* (*I.A.*, 19).

A [As to the first part, the student is to discuss how the uniformity of nature and the law of causation constitute the grounds of induction He is also to discuss whether these are inductions or not, giving different views, See QQ. 25 & 28]

It is in induction alone that the conclusion is wider than the premisses And it is precisely for this reason that formal logicians discard such a conclusion as being unjustifiable. Material logicians, on the other hand, regard it as valid, provided the induction be based on the uniformity of nature Such a conclusion is, therefore, as valid as the uniformity of nature But the uniformity of nature is itself an induction, and therefore, cannot be held as absolutely certain, but only more or less probable The validity of such a conclusion, therefore, is much less than that of demonstrative truths, though sufficient for the practical needs of life me Therefore, the real difference between the two is that while in both of them we alter the circumstances, in experiment we do so in a *much greater degree* than in observation. Hence we see that the difference between the two is one of degree, and not of kind.

Bain defines observation as *finding* a fact, and experiment as *making* one This simply means that in the former we are passive, and in the latter active—in the former the conditions are *found* in nature, while in the latter, they are *made* by us. We have considered above how far this is true.

⁂ 43 Q *Explain the comparative advantages of observation and experiment as methods of scientific investigation* (*B A 06*).

A Advantages of Observation over Experiment (Defects of Experiment) —

1 Observation is our only recourse in certain sciences, *e g*, Astronomy, where experiment is impossible. We cannot, for example, make experiments upon the heavenly bodies, as they are out of our reach The scope of observation is thus wider than that of experiment.

2 Observation is our chief recourse in certain sciences, *e g*, Politics, where experiment is often dangerous. Thus, when we are to ascertain the cause of famine or of mutiny we are to depend upon observation, for in such a case experiment is more or less risky

3 In observation we can proceed from the cauee to the effect, as well as from the effect back to the cause, but in experiment we can proceed only from the cause (supposed or real) to the effect It is true that when an effect, *e g*, constipation, is given, I may by experiments trace its cause, but that in such a case I have to go on supposing probable causes one after another and carry on experiments in each case, until I hit upon the right cause. Hence in such a case, too, I proceed from a cause, though it is a *supposed* one. When there is no means of guessing a cause experiment fails altogether

Advantages of Experiment over Observation (Defects of Observation) :—

1 In experiment we can *reproduce* as many instances as required, but in observation we are to depend upon the bounty

of nature Thus we can observe, by means of experiment, the behaviours of any two elements, say oxygen and nitrogen, when combined, as often as it suits our purpose ; but we have to wait indefinitely for an instance of earthquake, or lunar or solar eclipse.

2 In experiment we may *suitably vary* the circumstances so as to eliminate irrelevant phenomena, but in observation we are to depend upon nature for a suitable variation, and nature is not very liberal to give us a variation so as exactly to suit our purpose. [The variation of circumstances is essentially necessary to ascertain the causal relation. (See Q 15)]

3. In experiment we may *isolate* a phenomenon so as to observe its separate behaviours, but in observation we are to depend upon nature, and in nature a phenomenon is often hopelessly mixed up with other phenomena [The isolation of phenomena is essentially necessary to ascertain the causal relation (See Q 15)]

4. In experiment we can observe with coolness and circumspection, because the object is under our control, while in observation we are often taken by surprise, and the object disappears even before we have sufficient time to study its minute features

44 Q *Induction derives its premises from observation and experiment Describe and exemplify these two processes showing clearly the difference between them. In what does the superiority of experiment as a source of premisses consist?* (*I. A*, 13) *Distinguish between observation and experiment Point out the advantages of the latter over the former Has the former any advantages over the latter? Fully discuss the question,* (*I A.*, 15) *How does experiment differ from observation? In what respects is experiment superior to observation? Has observation any advantages over experiment? If so, what?* (*I A.*, 19)

A [See Q 42 and 43]

45 Q *Define observation and experiment, giving examples of each, and explain why these processes require treatment in Inductive Logic What are the advantages of the latter over the former? What sciences depend mainly on observation, and why? What sciences depend mainly on experiment, and why?* (*I A.* 09) *Distinguish between Observation and Experiment, and point out their importance in inductive enquiry Do they alone justify*

an inductive generalisation? Illustrate the fallacies which arise from their wrong use (I A, 21).

A. [As for the definition, distinction, and advantages, see QQ. 42 and 43]

These processes require treatment in Inductive Logic not on their own account, but because they constitute the material grounds of induction—they are the sources from which the premisses of induction are derived, that is to say, the particular facts from which we draw the inductive inference, *e. g*, A has died, B has died, and so forth, are given by observation and experiment Hence we see their importance in inductive enquiry.

They do not alone justify an inductive generalisation, but must be aided by the law of the uniformity of nature in order to that end.

[As for the fallacies incidental to them, see Q 175]

Sciences mainly depending on Observation :— Those sciences in which the materials are largely out o our reach or control, or in which experiments are more or les fraught with danger, are necessarily based mainly on observation. Examples :—Astronomy, Geology, Mateorology Biology (Zoology and Botany), History, Sociology, Psychology, Politics, and Economics [In recent times experiment have been introduced into Psychology]

Sciences mainly depending on Experiment.— In those sciences in which we do not find suitable isolation, variation, and combination of circumstances in nature experiment is our main recourse Examples —Physics Chemistry, Physiology, Anatomy, and Medicine

✓ **46 Q** *Distinguish between Observation and Experiment State briefly and illustrate the reason for combining these tw processes* (*I. A*, *09*)

A In observation we cannot secure suitable isolation o phenomena or variation of circumstances, without which th causal relation cannot be established Hence observation cannot generally establish causation. Its chief value consists i the suggestion of hypotheses regarding the probable causes which hypotheses are proved by experiment Suppose, I a to discover the cause of malaria. I visit several places in whic it prevails, and observe that these places are infested b anopheles mosquitoes But this does not prove that these mosquitoes are the cause of malaria; it only suggests a hypothesis. Now, if I can make experiments with these mosquitoes, and find that their biting is followed by malaria in an otherwise non-malarious place, then the causal relation is established beyond question. Thus we see that in the discovery or proof of the causal relation experiment is essentially necessary, and observation is preliminary to it, showing the necessity of combining them together

✓47 Q *What do you mean by active observation or natural experiment?*

A In certain cases of observation we are comparatively active, i e, we introduce certain conditions with a view to facilitate the process of observation, as when we use a telescope to observe a heavenly body Since such observation lies midway between pure observation and pure experiment, it is sometimes called active observation or natural experiment

CHAPTER VI.

THE EXPERIMENTAL METHODS.

Q. *Why is it necessary to deal with the Experimental Methods in Logic?* (*I A.*, 10). *What are those methods?*

A. It is necessary to deal with the Experimental Methods in Logic, because (*a*) they *prove* causal connexion by eliminating irrelevant phenomena, (*b*) even when they fail to prove causal connexion, they establish the laws of co existence, and (*c*) they suggest hypotheses, and thereby lead to the *discovery* of cause

These methods are five in number, *viz*, (1) Method of Agreement, (2) Method of Difference, (3) Joint Method, (4) Method of Concomitant Variations, and (5) Method of Residues [Mill speaks of *four* methods, though he discusses all the five, obviously for the reason that he includes the Joint Method in the Method of Agreement.]

N B.—From the use of the term Experimental, it should not be considered that they are the methods of experiment only, and not of observation *Experimental* is used in the sense of *Experiential*, i e relating to experience, so as to include both observation and experiment. They are also called Methods of Elimination (because they proceed upon the elimination of phenomena by varying the circumstances) or Inductive Methods

⁂ 49 Q *Explain the M of Agreement. Give symbolical and real examples of it How is the method frustrated? Give an example What is the remedy?* (*I A*, 14). *Explain and illustrate by a certain example the M of Agreement Point out the difficulty connected with the employment of the method* (*I A*, *15*) *Illustrate the operation of the plurality of causes in the application of the M. of Agreement, and indicate how it may be counteracted* (*I A*, 10) *Explain how Plurality of causes affects the application of the M. of Agreement.* (*I A.*, 18) *State the canon of the M. of Agreement, and illustrate its use by a concrete example* (*I A*, 19) *Explain and illusrate the M of Agreement What are the defects of the method, and how can they be remedied?* (*I. A.*, 21).

A. Canon :—*If two or more instances of a phenomenon under investigation have only one other circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon.*

Here we have a number of instances (at least two) of a given phenomenon The instances differ in all respects except in respect of another phenomenon From this we conclude that this phenomenon, which is common to all the instances, is the cause or effect of the given phenomenon, according as it is the antecedent or the consequent,

Symbolical Example —A B C ..*a m n*
A B D . *a x y*
A E F....*a p s*
.A and *a* are causally connected.

Here take *a* to be the phenomenon under investigation Three instances of it are given in which the only other circumstance present is A Therefore, A is the cause of *a* The reason is plainly this :—Neither of B, C, D, E, F can be the cause of *a*, because *a* does not disappear when they are eliminated Now, because *a* must have a cause, therefore, A is the cause, which has so far *invariably* preceded it.

Concrete Examples —(1) Suppose we are to ascertain the cause of cholera We observe several instances in which we find that the only antecedent present in all the instances is the use of foul water Hence we conclude that foul water is the cause of cholera (2) The north east wind is injurious In several instances of the blowing of this wind, the only common circumstance found is this that it blows very close to the ground, thus carrying many harmful germs This circumstance is, therefore, regarded as the cause (3) In all cases of the conversion of solid bodies into liquids and of liquids into gases the only common circumstance is the application of heat. Heat is, therefore, regarded as the cause of such conversion

Defects of the Method :—Mill mentions two defects, *viz*, (1) The *characteristic* imperfection, *i. e* the defect which is inherent in the very principle of the method, and (2) The practical imperfection, *i e*, the defect arising from the practical application of the method.

(1) The characteristic imperfection is due to the possibility of the plurality of causes. The method fails, if the

plurality of causes be admitted (which, for practical and even for scientific purposes, is indeed admitted). Thus in the above symbolical example, in the first instance C, in the second D, and in the third F may be the cause of *a*. When, for example, a doctor cures different cases of fever by different medicines, which are all coloured red, I may be misled by this method to think that because redness alone is present in all the instances, therefore it must be the cause of cure.

Remedy —Two remedies are possible .—(*a*) The multiplication of instances If I take a sufficiently large number of instances, say 100, of *a*, in which only A is the commo antecedent, I cannot reasonably say that in each of these 10 cases *a* has a different cause, and that A is only accidentall present in all these cases. (*b*) the application of the Joint method [We shall consider it when we discuss this method

(2) The practical imperfection arises from the possibilit of a hidden antecedent. Thus it may be the case that there is a hidden antecedent, say X, which is the cause of *a*, whereas A is present only accidentally, or perhaps A and *a* are the co effects of X Thus the presence of a specific microbe has been the real cause of many diseases But as it was not detected those diseases were wrongly put down to changes of temperature, indigestion, etc

Remedy :—This defect cannot be completely cured Bu the chance of a hidden antecedent may be more or less reduce (1) by careful observation, and (2) by multiplying the instances The more I multiply the instances, the greater is th chance of detecting a hidden antecedent, if any

But however cautiously I may direct my observation, th chance of a hidden antecedent, say X, cannot be barre altogether In that case A and *a* may be the co-effects of X Hence this method cannot finally establish causation, but onl co-existence.

50. Q *Explain the importance of the M of Agreement.*

A Though this method cannot finally establish causa relation between two phenomena, say A and *a*, yet it suggest that A may *probably* be the cause of *a*, thus paving the wa for applying a surer method, *e g*, the Joint Method Henc this method has a great *suggestive* value, and leads to discovery by suggesting hypotheses as to the probable causes

51 Q *What are the characteristics of the M of Agreement ?*

A. (I) This method is chiefly a method of observation, because it does not require instances of any special or definite kind,—any instances in which the given phenomenon occurs may be examined for the purposes of this method (2) It is a method both of proof and of discovery It tends to discover causes by suggesting hypotheses regarding probable causes As a method of proof, its value is indeed very small, as it suffers from two great defects

52 Q *Compare the M of Agreement with Induction per Simple Enumeration "Agreement for establishing an ultimate law is not the same as the Method of Agreement for establishing cases of causation" (Bain) Explain.*

A ('Agreement for establishing an ultimate law' means Induction per simple Enumeration, because all ultimate laws, according to Mill and Bain, are based upon it Hence we are to distinguish between Induction per Simple Enumeration and the Method of Agreement)

Points of Similarity —(1) Both are based on observation. (2) In both of them the instances *agree* in the presence of two phenomena, say, A and *a* (3) In both, the greater the number of instances, the greater is the probability of the conclusion (4) Neither can conclusively prove causation Both can prove only the laws of co existence.

Points of Difference —(1) The Method of Agreement proceeds upon the elimination of the irrelevant phenomena by varying the circumstances, whereas in Induction per Simple Enumeration there is no such elimination Hence the former is scientific, and the latter, unscientific The value of the latter depends solely on the *number* of instances, whereas the value of the former depends to a large extent on the *character* of the selected instances (2) From the above it follows that the conclusions of the former are more probable than those of the latter.

58 Q *If it is true that the same cause always produces the same effect, does it follow that the same effect is always produced by the same cause ? Give your reason for your answer, and support it by illustrations. Show that the principle involved here gives rise to difficulty in the drawing of inferences, giving* *examples. How may the difficulty be overcome? Give examples.* (*I. A.*, *11*)

A [The student is to discuss at length if the doctrine of the plurality of causes is valid or not, and show how the plurality of causes vitiates the M. of Agreement, and how the defect is to be remedied]

⁂ 54 Q *Explain and illustrate the M of Difference, showing how it is oftener than any other the basis of ordinary inferences.* (*I A.*, *15*). *State in your own words and illustrate with examples (symbolical and real) the M. of Difference. Show by a common instance that the method plays a great part in every day inference,* (*I A* , *13*) *Explain and illustrate the M. of Difference, showing its close connexion with experiment and practical life. Point out how a careless use of this method leads to the fallacy of post hoc ergo propter hoc.* (*I A* , *20*)

A. Canon ·—If an instance where a phenomenon occurs and an instance where it does not occur · have every circumstance in common save one, that one occurring only in the former, the circumstance in which alone the two instances differ is the effect, or the cause, or a necessary part of the cause, of the phenomenon

Here we have only two instances of a given phenomenon. The instances agree in all respects except in respect of another phenomenon, which is present in the first instance, but absent from the second. From this we conclude that this phenomenon, in which the two instances of the given phenomenon differ, is the cause or effect of the given phenomenon, according as it is the antecedent or the consequent

Symbolical Example .—A B C ..*a* b c.

B C...b c.

∴ A is the cause of *a*

Here neither of B and C can be the cause of *a*, for they are not its invariable antecedents, because they occur in the second instance, but *a* does not occur Now because *a* follows A both in its presence and in its absence, therefore A is the cause of *a*

Concrete Examples :—(1) When a clock ordinarily strikes we hear a sound. But when it strikes in a vacuum (the air being withdrawn by an air-pump), we hear no sound.

Hence we conclude that air is the cause of sound (2) When I put on my eye glasses I see things clearly, but as I put them off I see things indistinctly Now, because the other circumstances which may possibly be connected with vision are unchanged, I conclude that wearing the eye glasses is the cause of clear vision.

This method plays a greater part in our every-day inferences than any other method Indeed, most of our inferences in practical life are rightly or wrongly based upon this method Thus, when upon the dismissal of a Headmaster discipline is restored in a school, we regard the Headmaster as the cause of the breach of discipline When after sun set I feel darkness and cold, I conclude that the sun is the cause of light and heat When on shutting up the eyes I see nothing, I conclude that the opened state of the eyes is the cause of vision.

A careless use of this method, however, is very likely to lead to the fallacy of post hoc etc For, in the complex affairs of life and nature it is very probable, unless we are extremely careful, to overlook the real cause and mistake a phenomenon for the cause which was accidentally present in the first and absent from the second instance Thus, when from the disappearance of a particular man theft disappears from a village, we are apt to regard that man as responsible for the theft, forgetting that the cause may be something else In such a case our argument comes to this :—Because theft ceases *after* this, therefore it ceases *on account of* this, thus committing the fallacy of *post hoc ergo propter hoc.*

55 Q. *In what does the superiority of the M. of Difference over the M of Agreement consist?* (*B A*, *08*) *What advantage has the M of Difference over the M of Agreement?* (*I. A*, *18*).

A (1) The M of Difference is simpler than the M of Agreement, because the former requires *just* two instances, while the latter *at least* two instances (2) The M. of Difference does not suffer from the effect of the plurality of causes, for neither B nor C (in the above symbolical example) can be the cause of *a*, because their presence is not followed by the presence of *a* in the second instance (3) If the requirements of the canon are strictly complied with, that is, if we can be sure that the two instances of the phenomenon differ only in one other circumstance (and in nothing else), then this method yields the surest conclusion But not so the M. of Agreement (4) This method is chiefly a method of experiment, while the M. of Agreement is chiefly a method of observation. Hence this method possesses all the comparative advantages of experiment over the M. of Agreement.

56 Q. *What advantage has the M. of Agreement over the M of Difference? (I A., 18)*

A (1) The M of Difference requires two instances of a definite and special sort, while in the M. of Agreement any instances in which the given phenomenon occurs may be taken into account (2) The M of Agreement, being a method of observation, possesses all the comparative advantages of observation over the M. of Difference

57 Q. *Why is the M of Difference chiefly a M. of Experiment?*

A. It is chiefly a method of experiment, because it requires two instances of a very special and definite kind, which we seldom meet with in nature The conditions of this method are very stringent, It demands that the two instances will agree in all respects, so far as the particular case is concerned, except in respect of the given phenomenon and another phenomenon But we can hardly expect nature to present us with such a clear-cut couple of instances.

58 Q *Explain the canon of the Double M of Agreement (Joint Method or the Indirect M of Difference, as it is also called) and illustrate your answer by a concrete example (B. A, 07) What is the Joint Method? Illustrate it by concrete examples (I A., 15) When is it necessary to employ the Joint M of Agreement and Difference? State and illustrate this method by a concrete example. (I A, 16, 19).*

A **Canon** :—If two or more instances in which the phenomenon under investigation occurs have only one other circumstance in common; while two or more instances in which it does not occur have nothing in common save the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect or the cause, or a necessary part of the cause of the phenomenon.

In this method we have two sets of instances, one positive and the other negative. The instances of the positive set agree in the *presence* of the given phenomenon and one other circumstance, and the instances of the negative set agree in their *absence*. From this we conclude that the circumstance, which accompanies the given phenomenon both in its presence and in its absence, is its cause or effect, according as it is the antecedent or the consequent.

Symbolical Example —

$$\left.\begin{array}{ll} A\ B\ C \ldots\ldots & a\ b\ c \\ A\ B\ D \ldots & a\ b\ d \\ A\ E\ F\ .\ \ldots & a\ e\ f \end{array}\right\}\ 1$$

$$\left.\begin{array}{ll} B\ K\ \ \ldots & b\ k \\ D\ P & d\ p \\ E\ M \ldots\ldots & e\ m \end{array}\right\}\ 2$$

A is the cause of *a*

Here we have two sets of instances The given phenomenon *a* occurs in the first set of instances, which have one other circumstance A in common. The instances of the second set, in which *a* does not occur, have nothing in common save the absence of A. Now, because *a* follows A both in its presence and in its absence, A is the cause of *a*, being an invariable antecedent.

N B —It should be noted that the negative instances must be *cognate* with the positive ones, *i e*, they must have some common factors, otherwise they will be of no value. Thus, in the above example B, D and E are common to the two sets

Concrete Examples .—(1) In searching for the cause of cholera, if I find that it follows the drinking of foul water (other circumstances varying), and that it is absent, wherever men do not take foul water, I conclude that foul water is the cause of cholera (2) If I find in several instances that the rise of price follows scanty supply (other circumstances varying) and that whenever there is an ample supply, price falls I conclude that scanty supply is the cause of the rise of price (3) In times of pox if we see that non vaccinated persons alone are attacked by it we conclude that vaccination is a good preventive

How the plurality of causes counteracted by this Method —This method is more or less free from the effect of the plurality of causes. If the negative instances be-

exhaustive, *i e.*, if they exhaust all the accompanying circum-ances, then it is altogether free from the defect ; otherwise is more or less free Thus in the symbolical example given ove, B, D, or E cannot be the cause of *a*, because they cur in the negative set without being followed by *a*. But ill the doubt remains that C or F may be the cause of *a* either of them occurring in the negative set). Now if we n secure any other negative instances in which C and F cur, then we are perfectly satisfied that neither of them is e cause of *a* Hence we see that if the negative instances exhaustive, then this method is entirely free from the efect due to the plurality of causes.

59 Q. *What are the merits and defects of the Joint ethod ?*

A **Merits** :—(1) The proof by the positive instances in e M. of Agreement is confirmed by the negative instances) It is more or less free from the effect of the plurality of auses

Defects —(1) The negative instances not being always xhaustive, the conclusion is not generally so certain as in the ase of the M of Difference (2) The chance of a hidden ntecedent lurks Hence, it cannot conclusively prove causa-ion

60 Q *Compare the Joint Method with the Methods of greement and Difference.*

A **Comparison with the M of Difference** :—(1) Two stances are required in the M of Difference, while two sets f instanses in the Joint method. (2) If the negative instan-es be not exhaustive in the Joint method, then its conclusion s far less certain than that of the M of Difference But if hey be exhaustive, then it yields almost as certain a conclu-ion as the M of Difference (3) It is a method chiefly of bservation, while the M of Difference, of experiment.

Comparison with the M of Agreement :—(1) oth are the methods of agreement, the one only positive, hile the other both positive and negative (2) The Joint M is nore or less free from the defect due to the plurality of causes 3) The Joint M. yields a surer conclusion, as the conclusion f the positive instances is confirmed by the negative ones. 4) In both there is a possibility of a hidden antecedent. ence they cannot finally establish causation, but only co-existence. (5) Both are chiefly the methods of observation, and as such have all the advantanges and disadvantages of observation

⁂ 61 Q *Expound by a concrete application the canon of the M of Concomitant Variations (B A, 06) Explain and illustrate the M of C Variations What are the circumstances under which it is specially applicable? (I A, 14) State in your own words the M of C Variations Of what other method is it a modification? Is it a method of observation, or experiment, or both? In what class of cases is it the only possible inductive method, and why? (I A, 11) When is it necessary to employ the M. of C Variations? Explain and illustrate the method, indicating its different forms (I A, 17).*

A **Canon** —Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation

In this method we have two phenomena, one antecedent and the other consequent, which rise and fall together, whence we conclude they are causally connected

Symbolical Example —A B C—*a* b c
A′ B C—*a′* b c
A″ B C—*a″* b c
A is causally connected with *a*

Here take *a* to be the given phenomenon, which varies in degree in the three instances We notice another phenomenon, *viz* A, varying correspondingly. Hence we conclude that A and *a* are causally connected

In the above example the accompanying circumstances remain the same. Carveth Read mentions another form, in which the attending circumstances vary —

A B C—*a* b c
A′ D E—*a′* d e
A″ E F—*a″* e f
A is causally connected with *a*

N B.—This method is based upon the *quantitative* aspect of causation Since cause and effect are equal or proportionate, it follows that if one of them varies the other will also vary in a corresponding manner Hence if any two phenomena, say A and *a*, are found to vary proportionately (whether the accompanying circumstances remain the same or not), they may be regarded as cause and effect

Concrete Examples :—(1) Since the weight of a body diminishes in proportion as it is carried away from the earth, the attraction of the earth is regarded as the cause of the weight (2) The column of mercury rises or falls in a barometer, according as the pressure of the atmosphere increases or diminishes Hence the atmospheric pressure is the cause of the rise or fall of the column. (3) The bulk of a body increases as its temperature rises Hence heat is the cause of the expansion of bodies

The Unique Applicability of this Method :—This method is specially applicable in cases of what Mill calls the Permanent Causes, that is, the causes which cannot be eliminated altogether, such as gravity, atmospheric pressure, heat, etc We cannot get an instance in which gravity or the atmospheric pressure is altogether absent. Therefore, in such a case we cannot apply the M of Difference, which requires a negative instance. But we can reduce the effect of gravity or of the atmospheric pressure by carrying a body away from the earth. Hence though we cannot secure the *complete* elimination of these permanent causes, we can secure their *partial* elimination, enabling us to apply this method alone.

Whether it is a Method of Observation or of Experiment, or Both —This method, as is evident from the symbolical examples given above, admits of two forms, *viz.*, (a) one in which the accompanying circumstances remain the same, and (b) one in which they vary. In the former case, it is a modification of the M of Difference, and in the latter case, of the M of Agreement. Now because the M. of Agreement and that of Difference are respectively the method of observation and that of experiment, it follows that this method is a method both of observation and of experiment

[As regards the Canon of Elimination on which it is based, and the Method of which it is a modification, See QQ 67, 58, 71]

62 Q. *What are the limits of the M. of C. Variations ?*

A (1) This method is applicable only in the case of *quantitative* variations, and is inapplicable in the case of *qualitative* variations. In other words, it applies when phenomena vary in degrees (*i e.* quantitatively), and not when they disappear altogether (2) In certain cases the corresponding variation holds good up to a certain limit, beyond which it fails Thus the concomitance of the rise of heat and the expansion of bodies holds good only up to a certain limit.

⁂ 63 Q *State the M of Residues fully with examples, symbolical and concrete Does it involve any element of deduction? Show how it may lead to discovery of new antecedents Give some examples of this (I A., 12)*

A **Canon**—Subtract from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, then the residue of the phenomenon is the effect of the remaining antecedents.

N B The above statement is made by Mill and other logicians. But this is only a half statement of the canon, *viz*, from the standpoint of the effect The following is the full statement :—Subtract from any phenomenon such part as is known by previous inductions to be the effect (or cause) of certain antecedents (or consequents), then the residue of the phenomenon is the effect (or cause) of the remaining antecedents (or consequents)

Symbolical Examples —A B C *a b c*
B C *b c*
. A is the cause of *a*

I observe now that A B C are followed by a b c By previous inductions I ascertained B and C to be the causes of *b* and *c* respectively Hence by subtraction I conclude that A is the cause of *a*

Concrete Examples —[See the examples of Neptune and argon given below].

Deduction involved in this Method —This method is mainly a deductive one. Present experience has very little to do with this method. All that I observe now is that certain antecedents are followed by certain consequents, the rest of the method being a process of calculation Thus in the symbolical example, all that I observe presently is that A B C are followed by *a b c*. Then I reason thus :—Previously I found B to be the cause of *b*, and C of *c*, therefore B C are the causes of *b c*. Now I find that A B C are followed by *a b c*, of which B C are known to be the causes of *b c* Therefore, the residual antecedent A must be the cause of the residual consequent *a* The main part of the method consisting thus in calculation or deduction, it is regarded to be specially a deductive method

How it leads to Discovery:—This method is a fruitful source of discovery It leads to discovery by suggesting a hypothesis in this way :—Suppose the scientists have inductively ascertained the cause of a particular phenomenon If now they notice something new in the phenomenon, then they have a reasonable ground to suppose that there must be also something new in the cause,and acting on this supposition they will discover the cause In this way argon was discovered 'Lord Rayleigh found that nitrogen from the atmosphere was slightly heavier than nitrogen got from chemical sources The search for the cause of this difference led to the discovery of argon.' Neptune was also discovered in a similar way It was found that Uranus deviated a little at some point from its calculated path. The search for the cause of this residual phenomenon, *viz.*, the deviation by means of a telescope directed in the quarter of deviation, led to the discovery of Neptune.

64 Q *How is the M of Residues related to the M of Difference?*

A The principle underlying these two methods is the same, the difference consisting only in the manner of getting the negative instance. Whereas in the M of Difference the negative instance is got by present observation and experiment, in the M of Residues it is got by deduction from previous inductions

65 Q. *How is it that the M. of Residues is applicable only in an advanced stage of sciences?*

A. Inasmuch as this method requires the results of previous inductions, it cannot apply until a good number of inductions have got established in a science Therefore, the greater the number of established inductions in a science, the greater is the room in that science for applying this method.

⁂ 66 Q *Discuss whether the inductive methods can furnish valid proof of causation (B. A H, 30) Examine the validity of the inductive methods as criteria of proof (B A H., 06).*

A (1) The M. or Agreement cannot prove causation, owing to the possibility of (a) the plurality of causes, and (b) hidden antecedents (show how) (2) In the Joint M., if the negative instances be exhaustive, then it is free from the defect of the plurality of causes But generally the negative instances are not thoroughly exhaustive , and hence this method also, to a more or less extent, suffers from the defect of the plurality of causes Besides, there is the possibility of a hidden antecedent, though to a less extent than in the M of Agreement. Hence this method also cannot finally establish causation, though its conclusions are more probable than those of the M of Agreement. (3) The M of Difference does not suffer from the defect of the plurality of causes If the condition of this method is strictly satisfied, that is, if the instances differ in nothing else than in the given phenomenon and a certain other antecedent, then this method conclusively proves causation But generally such a strict fulfilment of the condition cannot be secured, there remaining always the chance of a hidden antecedent Hence though theoretically it proves causation conclusively, practically it does not The remaining two methods cannot obviously establish causation finally, as they are but the modifications of the M. of Agreement and the M of Difference Hence we conclude that the inductive methods cannot furnish valid proof of causation

67 Q. *Reduce the Exp Methods to two fundamental methods of Elimination (B. A., H., 08) (Discuss the question whether Inductive Methods may be viewed as mere weapons of elimination) Examine the attempts to reduce them to one or two fundamental methods (I A, 21)*

A (1) The Joint M is nothing but Agreement in presence and in absence—the instances of the positive set agreeing in the *presence*, and the instances of the negative set, agreeing in the *absence* of the given phenomenon and its accompanying circumstance (A and a) Hence this method is a modification of the M of Agreement (2) The M. of Residues is the same as the M of Difference, the same principle underlies them, the difference consisting in the manner of selecting the negative instance—whereas in the M of Difference the negative instance is secured by direct observation and experiment, in the M of Residues it is had by deduction from previous inductions. Hence the M. of Residues is a modification of the M. of Difference

~~(3)~~ The M of C. Variations is a modification of the M of Difference, both depending upon the same principle of the elimination of the relevant phenomena (A and a), differing only in this that in the M of difference the elimination is complete, while in the M of C Variations it is only partial. Hence we see that at bottom there are only two methods, *viz*, the M of Agreement and the M of Difference, the other methods being reducible to one or other of these two

The Exp methods are not mere weapons of elimination. Had they been so, they would have been merely negative in character. But we all know that they have a positive aspect too, for they positively establish a causal connexion by such elimination.

68 Q *Show that the M of C, Variations is reducible both to the M of Agreement and the M of Difference*

A The M. of C Variations has got two forms .—

(a) One in which the accompanying circumstances remain the same, as—A B C a b c
A′ B C a′ b c
A″ B C...a″ b c

In this form it is the modification of M of Difference, because the instances differ in nothing else save in the degree of A and a.

(b) One in which the accompanying circumstances vary, as— A B C...a b c
A′ D E . a′ d e
A″ E F a″ e f

In this form it is the modification of the M of Agreement, because the instances agree only in the presence of A and a (though in varying degrees).

69 Q. *Is the M. of Agreement reducible to the M. of Difference, as done by C. Read ?*

A Read reduces the M. of Agreement to the M of Difference on the ground that the essential feature of the inductive methods, as distinguished from Induction per Simple Enumeration, is the *variation* (and *not agreement*) of circumstances. Hence difference is more essential than agreement, and as such the M. of Agreement is reducile to the M of Difference But this view is erroneous, for from mere difference we cannot draw a conclusion Agreement and difference are equally necessary,—none of them being reducible to the other

70 Q *What do you mean by Discovery and Proof? Are the Exp Methods the methods of discovery or of proof?*

A Proof supposes an already existing hypothesis. Thus when I am required to prove that mosquitoes are the cause of malaria, it is supposed that the hypothesis, *viz*, that mosquitoes may be the probable cause, is already there If there exists no such hypothesis, I have nothing to prove, for proof implies *something* to prove, and that something is a hypothesis But discovery supposes no such previous hypothesis To discover the cause of a phenomenon means that I have both *to frame a hypothesis* regarding the probable cause and *to prove* it to be the cause

It goes without saying that the Experimental Methods are the methods of proof, whether of the laws of co existence or of those of causation The question, whether they are, too, the methods of discovery, depends upon the question whether they can only prove existing hypotheses or can also *suggest* them; for if they both suggest hypotheses and prove them, then they are surely also the methods of discovery Now the M of Agreement and the Joint Method can *suggest* a hypothesis by observing that two phenomena, say A and a, are always found to go together (the other circumstances varying), and hence the antecedent A *might be* the cause of *a*. But a hypothesis is specially suggested by the M of C Variations, for when two phenomena are observed to vary together, we cannot but suspect a causal connexion between them The M of Residues has been a fruitful source of scientific discoveries Hence the methods are also the methods of discovery

71 Q *What are the Canons of Elimination? Show that each of them furnishes a Method of Enquiry into causation (B A, 97), Are the Exp Methods purely inductive? (B A. 05, H. 03, 06) Point out the particular aspect of causation on which each of the Exp. Methods is based (B A, 07) What are the two main principles involved in Mill's canons of the Experimental Methods? (I A, 10) Deduce the experimental methods from the law of causation (I A, 21).*

A. The Canons of Elimination are those principles which guide us in ascertaining the causes of phenomena by elimina ting irrelevant circumstances These principles are deduced from the definition of cause. Each of these principles furnishes one Exp. Method Hence the Exp. Methods are necessarily *deduced* from the law of causation There are three such canons, as mentioned by Bain

First Canon :—"Whatever antecedent *can be left out* without prejudice to the effect can be no part of the cause."

This canon is based upon the *invariable* aspect of causation, for an antecedent which can be left out without affecting a consequent is not an *invariable* antecedent, and, therefore, cannot be its cause

This canon furnishes the M of Agreement. Take the symbolical example :—A B C—a b c
A B D—a b d
A D E—a d e

Here B, C, D, and E can be left out without affecting *a*. Therefore, neither of them can be the cause of *a*. But because *a* must have a cause (Law of causation), A which is the invariable antecedent is its cause

Hence we see that the M. of Agreement is *deduced* from the *invariable aspect* of causation, as well as, from the law of causation as a whole.

Second Canon :—"When an antecedent *cannot be left out* without the consequent disappearing, such antecedent must be the cause or a part of the cause "

This canon is likewise based upon the *invariable* aspect of causation, for if a consequent follows an antecedent both in its presence and in its absence, such an antecedent must be an *invariable* antecedent, and as such the cause of that consequent

This canon furnishes the M. of Difference. Take the symbolical example —A B C—a b c
B C— b c

Here A cannot be left out without *a* disappearing, and therefore A is the cause of *a* Hence the M of Difference is also deduced from the *invariable* aspect of causation.

Third Canon .—"An antecedent and a consequent rising and falling together in numerical concomitance are to be held as cause and effect."

This canon is evidently based upon the *quantitative aspect* of causation, and it is the same as the M. of C. Variations

Hence we see that the M of Agreement and the M of Difference are *deduced* from the invariable aspect of causation, and the M of C Variations, from the quantitative aspect. Hence these methods are really *deductive* As the Joint Method and the M of Residues are the modifications of the M. of Agreement and the M of Difference respectively, they are necessarily deductive in their nature We conclude, therefore, that the Inductive Methods are not really inductive, but deduced from the law of causation

72 Q *'In the comprehensive law of causation, itself once established by induction, we have the instruments for eliminating causes and effects in the detail Explain this statement, and illustrate it by one example* (*I. A.*, 15)

A [This involved statement is quoted from Bain (See Bain's Inductive Logic, p. 46) By the expression 'the instruments for eliminating causes and effects in the detail', Bain simply means the Canons of Elimination which determine causes and effects in particular cases by eliminating irrelevant phenomena These canons are based upon the wider law of causation, and the law of causation is in its turn established by induction per simple enumeration Hence the statement simply means that the canons of elimination, which determine causes and effects in particular cases, are based on the law of causation, which in its turn is established by induction per simple enumeration As for how the canons of elimination are deduced from the law of causation, and how they furnish the Exp Methods which determine causes and effects, see Q 71. And as for how the law of causation is an induction per simple enumeration according to the empirical view, see Q 28]

73 Q *Show how intermixture of effects prevents the employment of the Exp Methods Do all the Exp Methods fail in such a case? By what other method can the difficulty arising from intermixture of effects be overcome?* (*I. A*, 11).

A Mill confesses that his Exp. Methods fail in cases of intermixture of effects, esp in the case of homogeneous intermixture. The methods require, as the symbolical examples clearly show, that phenomena remain isolated from one another in the form A B C—a b c Hence if the various effects are blended together, it is impossible to determine to which antece dent any one of these intermixed effects is due, and, therefore, the methods become inapplicable in such a case.

But sometimes in such a case the M. of C. Variations affords some help For, if we notice the concomitant variation of two phenomena under the greatest complications, we suspect a causal connexion between them Sometimes also the M of Residues may be of much use For when we notice some unexpected variation in a complex effect, *e.g.*, the path of Uranus, we are led to suppose an additional cause for such a variation, and direct our investigation accordingly But the method which can most successfully cope with intermixture of effects is, as Mill points out, the Deductive Method

74 Q *What objections are brought against the Exp. Methods by Dr. Whewell? How does Mill meet them?*

A **First Objection** :—'They assume the very thing which it is most difficult to obtain, *viz*, the reduction of an argument to a formula.' If we can reduce an argument to the formula A B C—a b c, and B C—b c, then every one understands that A is the cause of *a* Thus the methods do not help us where help is necessary, and come to help us where help is unnecessary

Mill's Answer —(1) If we already know a formula, it becomes easy to reduce facts to the formula Hence the methods are not useless, for they indicate the ways in which the facts are to be arranged

(2) Even when the facts are reduced to a formula, errors may be committed in drawing an inference, as is testifield to by the commonness of false inferences Hence the methods are not useless

Second Objection :—'No discoveries have ever been made by their means.'

Mill's Answer :—(1) This objection assumes too much. The Exp Methods are the sole methods of observation and experiment Therefore, to say that no discoveries have ever been made by these methods is equivalent to saying that no discoveries have ever been made by observation and experiment, which is absurd on the face of it.

(2) Even if they are not allowed to be the methods of discovery, they are unquestionably the methods of proof, and Logic is mainly concerned with proof, and not with discovery Hence the methods are not useless

CHAPTER VII.

THE DEDUCTIVE METHOD

75 Q. *What does Mill mean by the term Deductive Method?*

A The term *deductive method* literally means the method followed in Geometry, *viz*, deducing conclusions from the accepted definitions and axioms But in Logic the term is used by Mill in a different sense. It means deducing conclusions and verifying those conclusions by experience In other words, it means the combination of induction and deduction. Hence it should rather be called the combined method, as it is called by Jevons

76 Q *Indicate the aid given to induction by deduction* (*I A*, 18) *Explain and illustrate the utility of the Deductive method* (*B A. H*, 07)

A We know the Inductive methods fail in the case of intermixture of effects In such a case our only recourse is the deductive method, *i e*; the alternate application of induction and deduction Besides, we know that the Exp. Methods (*i e* induction) cannot give us sure conclusions owing to the possibility of hidden antecedents These defects can be cured by combining induction with deduction Indeed, the results of pure induction are more or less probable, and the probability can be converted into certainty, if induction is aided by deduction

Neither induction nor deduction is a satisfactory method by itself When they are combined, they become the actual method of scientific progress Induction is blind, and deduction is empty Each is imperfect by itself Suppose, I form a general proposition, *v z*, Women are unfit to serve in the army I may do this simply by reasoning deductively thus — 'Since women are of delicate constitution, they cannot possibly bear the hardships of a soldier's life Besides, being soft hearted, they must be moved by bloodshed Hence, they are unfit for a soldier's life But this conclusion, reached deductively, may not be found to be true Or, I may form this generalisation inductively, *i e*, by observing a number of cases in which women have been actually found unfit But such a generalisation is necessarily precarious. Because in certain cases women have been found unfit, it does not follow that they are necessarily unfit (Hence in order to make the general proposition unquestionably true, I shall not only calculate or reason deductively, but also verify the calculation (deduction) by experience (induction)) [The former method of pure calculation is called *geometrical method*, which is evidently barren]

Hence we see that sciences can attain satisfactory results by using the combined method, which alone is capable of solving the complicated problems of nature, society and politics.

⁂ 77 Q. *Explain the character of the deductive method and its scope in induction (B. A , 08) By what method can the difficulty arising from intermixture of effects be overcome ? Describe and illustrate this method fully (I A., 11). Mill and Bain think that three operations are implied in the full scope of the deductive method, viz , induction, deduction proper, and verification Explain the exact meaning of each, and exhibit their relation to one another, making your meaning clear by means of examples (I A , 12)*

A The deductive method consists of three steps :—

✓1. Inductive ascertainment of the laws of separate causes

✓2 Deductive calculation of the joint effect of these laws.

✓3 Verification of the calculated result by experience

When a complex effect is given, we first consider which laws, already established by inductions, are likely to apply in this case In case no such laws are known to exist, we are to frame hypotheses regarding such laws. Next, we calculate as to which effect will follow from these laws taken jointly Lastly, we are to verify our conclusions by comparing them with facts of experience.

For illustration we may take the common example of the path described by a projectile When we throw a ball forward we know that it is acted on by three forces, *viz.*, (a) the initial force, that is, the force with which I throw it, (b) the resistance of air, and (c) the force of gravity I know also the laws of these separate forces, *viz* , that the initial force tends to move it forward in a straight line, that the force of gravity tends to bring it down, and that the resistance of air tends to diminish its velocity Having ascertained these laws, I calculate with the help of mathematics that because the ball is at every moment acted on by a downward and a forward force, it will fall down gradually, *i.e*, it will describe a parabola Next, I verify this result by experiment, say, by cannon shot

These three steps are related to one another Suppose, the computed result does not tally with facts. In that case the result must be wrong The mistake may be due either to the process of calculation, or to the premises, *viz* the laws, or to both Hence, a revision becomes necessary The result arrived at after a careful revision of the process of calculation, or of the laws, or of both, if necessary, must again be verified by experience The revision will be repeated, until the calculated result is found to tally with facts, *i e*, verified by experience Verification is, indeed, the most important step

78 Q *Explain and illustrate the different forms of the deductive method*

A There are three forms of the deductive method, *viz*, direct, inverse, and geometrical

[The deductive method described in Q 77 is the *direct* one]

The nature of the Inverse Method, as compared with the Direct Method —In the direct deductive method we first compute the result from known laws, and then verify it by comparing it with observed facts It thus supposes a number of known laws But sometimes it happenss that no such laws are known to exist, from which we may calculate the result This is specially the case in History, Politics, Sociology, etc, where matters are extremely complex, and very few laws have yet been established In such cases, therefore, we are first to observe the laws and their joint results, and then calculate *a priori* why such results should follow from those 2 laws. This is the Inverse Deductive Method Thus we see that whereas in the direct method we first calculate the joint results of known laws, and then verify them by experience, in the inverse method we first observe the results of laws, and then calculate why such results will follow from such laws In 3 other words in the direct method calculation (*i.e.* deduction) goes before experience (*i e.*, induction), but in the inverse method experience goes before calculation—in the former the results of calculation are verified by experience, while in the latter the results of observation are verified by calculation—in the former deduction is verified by induction, while in the latter induction by deduction—in the former deduction is aided by induction, while in the latter induction is aided by deduction

Suppose I am to ascertain the cause of Revolution No laws are known to exist which are likely to apply in such a case Hence I am to observe several instances of revolution, and notice the laws and their joint effect Suppose I notice two common incidents in all cases of revolution, *viz* (a) that the people are hungry, and (b) that the government is tyrannical From this I should not at once jump to the conclusion that these two are the causes of revolution I should now calculate why that should be the case (this is the duductive stage) I calculate thus :—When people are hungry, they naturally blame the government, for it ought to have taken proper steps to avert famine. The government, on the other hand, far from relieving the suffering of the people, exacts their last farthings, because it cannot be carried on without money Hence no wonder that the people rise in rebellion Thus in this case observation is verified by calculation

N B—The direct method is also called *physical* method, because it is chiefly resorted to in physical sciences, for the evident reason that in physical sciences phenomena are comparatively simple and that a good many laws have been established by inductions The inverse method again is called *historical* method, because it is chiefly resorted to in historical sciences, such as history, politics, sociology, economics, etc, owing to the vast complexity of such sciences It should not be thought, however, that the physical method is not at all applied in historical sciences or that the historical method is not at all applied in physical sciences

Geometrical Method .—It is a purely deductive method consisting in the simple deduction unaided by induction, as when I lay down a proposition, *e g*, women are unfit to serve in the army, only by deductive calculation without verifying that by experience It is a simple application of a law to particular cases, as when I apply the general proposition 'All men are mortal' to the particular case of Ram, so as to conclude that Ram is mortal. This method is resorted to in mathematics, but is barren when applied in concrete sciences.

79 Q. *When is the Deductive Method employed in inductive investigations? Distinguish between the direct and inverse forms of this method* (*I A*, 17) *Briefly state and explain the Deductive Method* (*I A*., 18).

A. [See above]

80 Q *Show clearly how the deductive method is related to hypothesis, and estimate its importance in Logic* (*B A H*., 08, *Suppl*)

A In the deductive method we are to calculate results from known laws But when no laws are known to exist which are likely to apply in the present case, we are to substitute hypotheses Hence is the necessity of hypotheses in the deductive method

[As for the importance of the deductive method see Q 76].

81 Q *By what form of reasoning is it possible to ascertain the effects of composite causes? In what sciences and in what professions is the reasoning of this kind most essential?* (*I A* 09)

A. The effects of composite causes can be ascertained by what Mill calls the deductive method (Briefly explain the method)

This kind of reasoning is most essential in those sciences and professions where pure induction fails altogether owing to the great complexity of phenomena. As for the sciences, we may name History, Sociology, Politics, and Economics As for the professions, we may mention those of legislators, politicians, merchants, and medical men

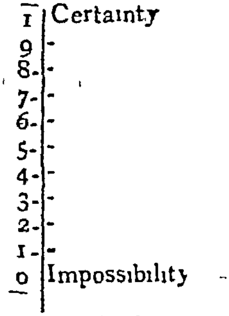
CHAPTER VIII

PROBABILITY AND CHANCE.

82 Q *State precisely what you mean by p * and by probable reasoning How can the degree of the p of propositions be expressed? Supposing the p of premisses of a syllogism is known, what will be the p of the conclusion?* (*I. A*, 16).

A. 'P is an ambiguous term. Usually, when we say that an event is probable, we mean that it is more likely, than not, to happen But scientifically an event is probable, if our expectation of its occurrence is less than certainty, as long as the event is not impossible' (C Read)

In the adjoining scale, suppose an event, say x, to be certain when at 1, and impossible when at 0. Now if x be above ·5, that is, above the middle, then it is popularly said to be *probable*. But if it be below ·5, say at ·4 or ·2, then it is ordinarily said to be *improbable* But scientifically speaking, if x be above 0 and below 1, then it is said to be probable If it be at ·2, then it is more probable than if it be at ·1, and if at ·3, then more probable than if at ·2, and so on If at ·8 or ·9, it is highly probable So we see that p admits of degrees



The degree of p may be expressed either as a fraction, or as a proportion Suppose that 3 men out of 16 live upto 70. Then the p of each man's living upto 70 is $\frac{3}{16}$ Or, we may express it as a proportion If 3 men out of 16 live upto 70, then 13 men do not Therefore, the p of each man's living up to 70 is 3 for and 13 against, *i.e*, 3 : 13 If out of every 100 men 2 die of fever, then the p of each man's dying of fever is $\frac{1}{50}$, or 1 for and 49 against, *i e*, 1 : 49

A probable reasoning is an inference drawn from probable premisses. From the premisses "All Englishmen are patriots,

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* The letter p will be used for probability for the sake of abbreviation.

John is probably an Englishman " I may draw the conclusion, 'John is probably a patriot' Reasoning based upon approximate generalisations is probable reasoning If both the premisses are probable, then the conclusion is less probable than either of them

If the p of the premisses of a syllogism is known, that is, if it can be expressed as a fraction, then it is easy to determine the p of the conclusion If the p of one premiss be $\frac{1}{3}$ and that of the other $\frac{1}{2}$, then the p of the conclusion is $\frac{1}{6}$, the rule being that the p of the conclusion is the product of the ps of the premisses

⁂ 83 Q *Give with examples the rules for the calculation of probabilities* (*I A*, *15*) *Indicate what is meant by a calculation of probabilities* (*I A*, *20*)

A In certain cases we may ascertain the ps of separate events by observation Now, if the range of observation is wide enough, we may, with some degree of accuracy, represent such separate ps in terms of fractions And when such is the case, we may, by deductive computation, ascertain the p of the concurrence of any such probable events or of their joint or alternative effect The following are some of the rules regulating the processes of such calculation of ps under certain particular circumstances —

1 'The probability of the concurrence of two independent events is the *product* of their separate probabilities' Suppose 2 days in 3 are dry, and one in three has a westerly wind Then the p of each dry day having a westerly wind is $\frac{2}{3} \times \frac{1}{3} = \frac{2}{9}$, or 2 for and 7 against, *i.e*, 2 : 7.

2 'The p of the occurrence of one or other of two events that cannot concur is the *sum* of their separate ps' The death of a man cannot be due to both burning and drowning, so that these two events *viz*, death caused by burning and death caused by drowning, cannot concur Now suppose one man out of 500 is burnt to death, and 1 out of 1000 finds a watery grave Then the p of one man's being burnt or drowned is $\frac{1}{500} + \frac{1}{1000} = \frac{3}{1000}$, or 3 for and 997 against, *i e*, 3 : 997.

3 The rule for the collective value of independent testimonies in the favour of a fact is to subtract from one the product of the fractions representing their separate improbabilities If a witness speaks four truths in five cases, the p of his testimony being true is $\frac{4}{5}$, and so the improbability of his

testimony being true is $\frac{1}{5}$ If two such witnesses bear the same testimony in favour of a fact, then the p of that fact being true is $\frac{24}{25}$ [$1-(\frac{1}{5}\times\frac{1}{5})$], or 24 for and 1 against, *i e.*, 24 1

4 The rule for the deterioration of testimony in passing from one person to another is to *multiply* the *fractions* expressing their separate probabilities If A speaks the truth 3 times out of 4, the fraction is $\frac{3}{4}$ If B speaks the truth 4 times out of 5, the fraction is $\frac{4}{5}$. Now, if B tells me that Ram has died, having heard it from A, then the p of Ram's having died is $\frac{3}{4}\times\frac{4}{5}=\frac{3}{5}$, or 3 for and 2 against, *i e*, 3 2

84-Q. *What is probable reasoning? Discuss the relation of probability to induction State and illustrate the rules for the combination (calculation) of probabilities* (*I A*, 16)

A Probability and induction :—Formal logicians, *e g*, Jevons, regard all inductions as but probable The reason is obvious Even those inductions which are based on the experimental methods cannot yield sure conclusions owing especially to the possibility of hidden antecedents Besides, there is no knowing that the course of nature will for ever remain unaltered, the whole fabric of laws may be changed in the twinkling of an eye, if it is so please God All inductions are, therefore, bare probabilities

There can be no doubt that strictly speaking, this is a correct view of the matter Yet we must say that for all human purposes, both practical and theoretical, induction yields conclusions which may be regarded as certain, though not so certain as that yielded by demonstrative reasoning In fact, induction stands midway between demonstrative and probable reasoning Demonstration gives necessary truths, probable reasoning problematic truths, and induction assertory truths It will, indeed, be a gross misuse of language to say that the induction 'Man is mortal' is probable in the same sense as the prop 'Ram will die to-morrow' is probable.

Although, as said above, induction is distinct from probability, we may make inductions of probabilities Thus, such conclusions as most cases of cholera are fatal, every year a certain percentage of men commits suicide, every five years there is an out break of pox in Calcutta, and so on, are only probable inductions based on statistics

[For the rest of the question, see above]

85 Q. *Given two premisses of the form 'Most B's are C and most A's are B,' can any inference be drawn? If so, of what kind? And on what conditions will its value depend? Give examples* (*I A*, 10)

A From approximate generalisations, such as the premisses of the form given, we can draw a conclusion But such a conclusion is of a *probable* kind, the conclusion being even less probable than either of the premisses Such inferences are not ordinarily of great value But if we can state the precise exceptions to these generalisations, that is, if we can ascertain the circumstances under which most A's are B, and most B's are C, then we can convert them into universal propositions and deduce from them a conclusion which is certain, and consequently of much value Thus the proposition, 'Most civilised people are self-seeking' may be converted into a universal proposition by stating its exception, *viz*, 'All civilised people except the God fearing are self-seeking,' and the proposition 'Most Indians are civilised' may be so converted thus 'All Indians except the non-Aryans are civilised' Now, from these two propositions I may with certainty draw the conclusion that 'All Indians except the God-fearing ones as well as except the Non Arayans are self seeking' Even if we do not know the exact nature of the exception, but know the conditions sufficiently so as to be able to express the probability as a fraction or a proportion, the conclusion is of some value Thus if we can say that 90 p c of civilised men are self seeking, and 80 p c of Indians are civilised, we can draw the conclusion by calculating p. 90 p c means $\frac{9}{10}$, and 80 p c. means $\frac{8}{10}$, and hence the conclusion is that 72 p. c of Indians are self seeking ($\frac{9}{10} \times \frac{8}{10} = \frac{72}{100}$) Hence the value of such an inference depends upon two conditions, viz, (1) If we can determine the precise *nature* and *extent* of the exception, its value is very great, and (2) if we can ascertain not the nature, but only the extent of exceptions, so as to be able to state the propositions quantitatively, its value, though not so great as in the above case, is not negligible

86 Q *What is meant by Probability? What kinds of inference are of demonstrative character, and what kinds are merely probable? Explain the reason in each case, and give examples* (*I A*, 11)

A (As for the meaning of p and probable reasoning see Q 82. As for demonstration, see Ch XVI).

87 Q *Distinguish between Induction and Probability What are the logical grounds of the latter? Explain and illustrate any two rules of probability by which definite conclusions may be arrived at* (*I A*, 19)

A [For the first part see Q. 84, and for the last Q. 83.] Logical Grounds of Probability —P may be based on statistics Such probable inferences, as 'Every five years there is an epidemic of small pox in Calcutta,' 'Every year there are so many unstamped letters, so many cases of suicide, so many cases of snake bite', and so forth, are based on statistics Such inferences are, however, very precarious P may again be based on calculation If we know the laws of the causes operating for and against an event, we may compute the probability of its happening. Certain rules have been formulated with a view to help us in such computation. [As for rules for the calculation of prabability, see Q 83]

The probability determined by any one of the above two methods evidently is not very great Higher probability can be secured by combining, if possible, the above two methods, *i e*, by verifying the results of calculation by statistics

⁂88 Q. *What is meant by Chance? Give examples. How is it eliminated?* (*I A.*, *15*). *Is there such a thing as chance? Discuss the relation between casual and casual connexion* (*I. A*, *20*)

A 'Chance was once believed (even by such a philosopher as Aristotle) to be a distinct power in the world disturbing the regularity of nature' Thus chance was believed to be opposed to law, esp the law, of causation. 'To happen by chance' meant 'to happen without a cause' But in modern times we do not believe that an event can be uncaused But though an individual event cannot be uncaused, yet coincidences of events, Mill says, can be uncaused. Take an example I sneeze, and my neighbour dies just after. Here neither my sneezing nor my neighbour's death is uncaused, but the coincidence of these two events is uncaused, *i e*, casual and not causal Hence Mill says that chance applies not to separate events, but to coincidences or conjunctions (*i e.*, sequences or co existences) of events. Hence he defines chance as conjunction of events which are not related through causation.

Strictly speaking, as Read observes, even such coincidences of events are not uncaused But their causes are so remote that we cannot trace them even by our utmost effort. Hence for all human purposes they are regarded as uncaused

From the above it is evident that casual connection is opposed to causal connexion, though, as seen above, in the last analysis the former is to be deemed an imperceptibly remote form of the latter

Elimination of Chance —Let us first consider the general case, *viz*, how to determine whether a particular conjunction of events, say the coincidence of a dry day and a day with westerly wind, is casual or causal What we are to do in such a case is to observe a large number of instances, so as to see whether they coincide with one another more often than chance can account for If so, then we believe that the coincidence is causal, and not casual Hence the rule is —"Consider the frequency of the events separately, and how great frequency of coincidence must follow from that, supposing there is neither connexion nor repugnance. If there is a greater frequency, there is a causal connexion ; if less, repugnance" In the above example, suppose two days out of seven are dry, and three days out of seven have a westerly wind Now, if these two events are neither inconsistent (repugnant) nor connected, that is, if they are independent, then they must coincide six times in forty-nine days ($\frac{2}{7}\times\frac{3}{7}=\frac{6}{49}$, see the calculation of the p of the concurrence of two independent events, Q. 83) Now, if they coincide more often than six times in 49 days, then a causal connexion may be presumed And if less often, repugnance is to be presumed In this case chance will account for six coincidences in forty nine days If there are more coincidences, then chance is eliminated, and causal connexion is to be presumed

But there are special cases, *viz*, when the effect of a constant cause is blended with the effects of casual accompaniments In such a case, to determine how much of the complex effect is due to the constant cause, we observe a large number of instances and take an average The average result is the part due to the constant cause, the variable remainder being due to the casual accompaniments For example, the temperature of a given day is due to the constant cause, *viz*, the sun, and many casual accompaniments, *e. g.*, cloud, wind, etc. In order to determine how much of the temperature is due to the sun we take an average of the temperatures of the different hours of the day, the average temperature being regarded as due to the sun.

89 Q. *How is the theory of chances applied to causation ?*

A "Given an effect to be accounted for, and there being several causes that might have produced it, but of whose presence in the particular case nothing is known, the p that the effect was produced by any one of these causes is as the antecedent p of the cause multiplied by the p that the cause, if it existed, would have produced the given effect". (Mill) Suppose X is the given effect, and it may be produced either by A or B Suppose the ps of A's and B's existence at the time x is produced are respectively $\frac{2}{3}$ and $\frac{5}{6}$. Suppose now that if A exists at the time, the p of its producing x is $\frac{3}{4}$. and that if B exists, the p of its producing x is $\frac{1}{2}$. Then the total p of A's producing x is $\frac{2}{3}\times\frac{3}{4}=\frac{6}{12}$, and that of B's producing x is $\frac{5}{6}\times\frac{1}{2}=\frac{5}{12}$. So we see that the p is in favour of A in the proportion of six to five, that is A is more likely to be the cause of x

CHAPTER IX.

ANALOGY.

⁂ 90. Q *Explain the nature of inference from analogy. Give both a symbolical and a concrete example, stating them in their simplest logical form On what conditions does the value of an analogical argument depend? (I A, 15) Explain and illustrate :—Inference by analogy (I A, 21)*

A Analogy may be defined 'as a kind of probable proof based upon imperfect similarity between the data of comparison and the subject of inference.' 'In it we rely upon some such vague notion of uniformity as that 'Things alike in some points are alike in others.' Analogy, as different from induction and as a distinct form of inference, supposes that two things from resembling in a number of points may resemble in some other point, which other point is not known to be connected with the agreeing points by a law of causation or of co-existence,' (Bain) The nature of inference from analogy may be indicated as follows :—(1) It is an argument from the particular to the particular It is thus distinguished from induction and deduction (2) The similarity upon which the argument is based is imperfect, that is to say, the points of resemblance between the two particulars (A and B in the symbolical example) are not very important for the purpose of the argument (3) No causal connexion is known to exist between any of the agreeing properties (*a*, *b*, *c*, *d*, in the symbolical example) and the property to be inferred (4) Therefore, the argument is only probable, and not certain

x
$a\ b\ c\ d\ e\ f$
Symbolical Example —A
$a\ b\ c\ d\ m\ n$
B

x
∴ B

Concrete Example :—Mars resembles the earth in respect of (1) being a planet, (2) moderate temperature, and (3) possession of an atmosphere, sea, and land. Therefore, Mars also resembles the earth in respect of *being inhabited*.

N B In this example, if it can be shown that Mars resembles the earth also in respect of *buildings*, then the argument will no longer remain probable, for buildings can be constructed only by rational creatures, and therefore it certainly follows that there must be rational creatures in Mars. But the argument will not be analogical in that case

Conditions of the Value of Analogical Argument :—Analogy can never reach certainty,—it can yield only a probable conclusion, the degree of probability depending on certain conditions With a view to draw an analogical inference two things are to be compared Now, these two things may be known to resemble each other in certain respects and differ from each other in certain other respects Besides, there are certain respects in which we may not know whether they resemble or differ from each other Hence the obvious conditions of the value of an analogical argument may be indicated as follows :—

(1) The greater the number and importance of the points of resemblance, the more probable is the inference. Thus the points of resemblance between man and the lower animal are more numerous and important than those between man and the plant, and hence the inference that animals feel pain as men do is more probable than that plants feel pain.

(2) The greater the number and importance of the points of difference, the less probable is the inference. Thus the points of difference between man and the plant are more numerous and important than those between man and the lower animal, hence the inference that the plant feels pain as men do is less probable than that animals feel pain

(3) The greater the number of unknown properties, the greater the uncertainty attaching to such an inference, and therefore obviously the less is its value

Thus we see that the strength or value of an analogical argument depends upon the number and importance of the points of resemblance, as compared with the number and importance of the points of difference, as well as, the number and importance of unknown properties Now, if *a* stands for resemblance, *b* for difference, and *c* for unknown properties, then we may represent the value as a proportion thus :—

$b+c$, *i e.*, $\frac{a}{b+c}$ Hence we see that the value of an analogy may be represented by a fraction having as its numerator the resemblances between the two things compared, and as its denominator the differences between them *plus* the number of unknown properties

⁂ **91 Q** *What is meant by analogy? Explain the nature of analogical reasoning, and show on what conditions the value of such reasoning depends Exhibit its relation to scientific induction.* (*I A.*, 09)

A [For the first part see above.]

Relation of Analogy to Induction —Points of Similarity ·—(1) Both are *inferences* (2) Both are based upon *similarity*. The inference from some men to all men (induction) and the inference from the earth to Mars (analogy) are both based on similarity, in the former case between some men and all men, and in the latter case between the earth and Mars

Points of Difference—(1) In induction we reason from the *particulars* to the *general*, but in analogy from the *particular* to the *particular*. (2) Induction is based upon deep seated similarity, but analogy upon *imperfect* similarity (3) In induction a causal connexion is shown to exist by means of the Exp Methods between the points of similarity and the property to be inferred, but in analogy no such causal connexion is known or shown to exist (4) Consequently, the value of an analogical argument is very small as compared with that of induction

92 Q *Distinguish between Analogy and Induction How is the strength of analogical argument measured?* (*I A*, 17) *How does induction differ from inference from analogy?* (*I A.*, 14)

A. [See above]

93 Q *Show how the value of an analogy may be represented by a fraction having as its numerator the resemblances between the two things compared and as its denominator the differences between them plus the number of qualities of which we are ignorant* (*I A*., 20).

A [Se Q. 90]

94 Q. *In what respects does reasoning from analogy fall short of inductive proof? Give examples of good and bad argument from analogy* (*B. A.*, 05)

A. [For the first half see above.]

An argument from analogy is good or bad according as the points of resemblance are more or less numerous and important, as compared with the points of difference and unknown points.

Examples of Bad Analogy —(1) Because the cow resembles man in respect of having eyes, ears, skin, nose, tongue, blood, and nerves, therefore it resembles man also in point of rationality. (a) Because a gramophone resembles man in respect of talking, singing, and laughing, therefore it resembles man in respect of consciousness

Examples of Good Analogy :—(1) The example of Mars (2) Because the cow resembles man in having the sense-organs and nervous system, therefore it resembles man in point of having the power of perception.

95 Q. *Explain the nature of the argument from analogy—what has it in common with and wherein does it differ from deduction and induction ? (B.A , 06)*

A. **Analogy and Deduction Compared :—**

Points of Likeness —(1) Both are *inferences.* (2) Both are based on similarity .

Points of Difference :—(1) In deduction we reason from the general to the particular, but in analogy from the particular to the particular (2) Deduction is base upon identity or perfect similarity, but analogy upon imperfect similarity Thus when I say, all men are mortal, Ram is man therefore Ram is mortal, Ram perfectly resembles man. (3) Consequently, as a process of inference deduction is certain, but analogy is only probable

[For the remaining part see above]

96. Q *Explain Whately's definition of analogy as resemblance of ratios or relations*

A. Analogy is now-a-days generally understood in the sense of the resemblance of two particular things. But formerly it was taken, as by Aristotle, Kant, and others, to mean the resemblance between the relation of one couple of things and that of another As Kant says, "Analogy does not signify as is commonly thought, an imperfect likeness between two things, but a perfect likeness of relations between two quite dissimilar things' Thus the Prime Minister may be said to be the pilot of the empire, the sovereign may be said to be the father of the state, England may be said to be the mother of her colonies, the undulation of air or ether may be said to be analogous to the wave of water, and so forth. Analogy, understood in this sense, may be expressed thus — Father family . sovereign · state. It means that the sovereign is in the same position with respect to the state as the father with respect to the family From this we may draw, rightly or wrongly, all possible conclusions suited to our liking or purpose, such as all subjects should implicitly obey the sovereign, as the members of a family implicitly obey the father It should be remarked that such resemblance is often vague and metaphorical, and consequently misleading

97 Q *Explain the nature of inference from analogy How does it differ from induction? Estimate its value.* (*I.A*, *15*) *Explain the nature of inference from analogy and estimate its value How does it differ from Induction?* (*I A*, *18*)

✓A **Value of the analogical reasoning** —The value of analogy, *as a mode of proof*, is very small, because (1) the argument is based on imperfect similarity, and (2) no causal connexion is known to exist between the resembling properties and the property to be inferred Hence it gives only a *probable* conclusion "No analogy can amount to full proof very few give even a high probability" (Bain) "It may afford", says Reid, "a greater or less degree of probability according as the things compared are more or less similar in their nature, but can afford only probable evidence at the best" But it has a high value, as a mode of *discovery*. On the ground of resemblance in certain respects, resemblance in another respect may be supposed; and acting on such a supposition a discovery may be made Mines are sometimes discovered by analogy. When a plot of land resembles in certain respects other plots where gold mines are known to exist, there is a presumption that it also contains a gold mine, and acting upon this presumption we may discover a gold mine there

[As for the rest of the question, see above]

CHAPTER X.

LAWS OF NATURE.

98 Q *What is meant by a law and a law of nature?* (*I A.*, 10).

A The original meaning of the term law was the command of a sovereign As such a command was intended to be *uniformly* obeyed by all the subjects, gradually the element *uniformity* became detached from command, and the term *law*, over and above its original significance, came to mean a *uniformity*. Hence, the term is used now in two senses. In Jurisprudence, it is used in the sense of the command of the supreme ruling power of the state, and in sciences, in the sense of uniform operation

A law of nature means a uniformity that we observe in the processes of nature All uniform operations of nature are the laws of nature The term *nature* is used here to include both the material and the mental world, so that a psychological law is as much a law of nature as a chemical or a biological law As examples of the laws of nature we may mention the laws of motion in physics, of definite and multiple proportions in chemistry, of pleasure and pain in psychology, and so forth

99 Q. *What is a law? Distinguish between a law of the state, a law of nature, and a logical law, illustrating your meaning with examples Science must assume that nature is subject to law, explain why it must do so* (*I A.*, 13)

A **Laws of State and Laws of Logic**:—(1) The former are enjoined by an authority and enforced by penalty; but the latter are not so. (2) The former are changeable, and as a matter of fact are often changed to suit the conditions of time and place, while the latter are unchangeable (3) The former are concerned with acts; but the latter with thought. (4) The former differ in different countries, but the latter are the same everywhere

Laws of Nature and Laws of Logic:—(1) The former cannot be violated; but the latter can (2) The former are *positive*, *i. e*, they merely state what actually take place in nature , but the latter are *normative*, i e they are the laws to which thought must conform in order that it may be valid,

Laws of state and Laws of Nature —(1) The former are enjoined by an authority and enforced by penalty , but the latter are not so. (2) The former are changeable, and as a matter of fact are often changed to suit new conditions that may arise , but the latter are unchangeable (3) The former differ in different countries , but the latter are the same everywhere. (4) The former can be violated , but the latter cannot

that nature is subject

Science must assume ... to Law —This means that the uniformity of nature is a postulate of Logic, and hence, of all sciences If there be no uniformity, no laws can be established. Indeed, all laws rest on the primary assumption of the uniformity of nature

[As for the meaning the term *law* see Q 98]

⁎⁎ **100 Q** *What are the laws of nature? Define and exemplify Ultimate, Secondary, Derivative, and Empirical laws showing their relation to one another To which class will those laws belong which are founded on the Method of Agreement? Give your reason with examples.* (I A., 12) *Explain — Law of Nature, Empirical Law* (I A , 15) *What to you understand by the laws of nature? Do they rest on any primary assumption? How are such laws* to be explained? *Explain and illustrate their different forms* (I A , 21)

A. All laws are not of the same degree of generality. Some laws are more general than others. For example, the law that all organised bodies are subject to decay is more general than the law that all men are moral. Laws are classified according to their degree of generality, those that are more general being placed higher than those that are less general The order of classification is as follows —

I. Axioms [See Q 104] Axioms are regarded by intuitionists as intuitively known But empiricists regard them as inductions per simple enumeration based on a wide range of uncontradicted experience in early life,

II Primary or Ultimate Laws —They are the laws of the highest generality, next to axioms Such are the law of Gravitation in Astronomy , the law of Definite Proportions in Chemistry , the law of Heredity in Biology ; and the law of Relativity in Psychology

III **Secondary Laws (called 'Middle Axioms or Intermediate Generalities' by Bacon)** They are those laws which are less general than ultimate laws, and have either been actually deduced, or are believed to be capable of being deduced, from those ultimate laws, *e g.*, the laws of tides, the law of the expansion of bodies by heat. They are divided into two classes :—

A **Derivative Laws** They are those secondary laws which have actually been deduced from higher laws, *e g.*, (1) The law of the rise of water in a pump, which has been deduced from the higher laws of the atmospheric pressure and the equal transmission of pressure by water in all directions (2) The law of the fall of bodies, which has been deduced from the higher law of gravitation These laws are evidently established on a combined method of induction and deduction.

(B) **Empirical Laws.** They are those secondary laws which have not yet been deduced from higher laws, but which, from their complex nature, are reasonably believed to be capable of being so deduced. They are the laws of which we do not yet know the why, being based upon induction per simple enumeration or the method of agreement Thus the laws that tom-cats with blue eyes are deaf, scarlet flowers have no fragrance, quinine cures fever, and so on, are all empirical laws.

N B Many laws which were at first empirical have since become derivative in course of scientific progress. The law of the rise of water in pumps, for example, was an empirical ar, because we did not know the cause of the rise Now because we have come to know its cause, that is, because we have been able to deduce it from the causal law, it has become a derivative law

Laws founded on the Method of Agreement·— Since the Method of Agreement (as also Induction per simple Enumeration) cannot establish causal relation, laws founded on it cannot be said to be derivative So long as such laws as 'mosquitoes are the cause of malaria,' 'a certain species of bacteria contained in water is the cause of cholera', and the like, are proved only by the M. of Agreement, they remain emperical laws

[As for the rest of the question see above].

101 Q. *To which class do those laws belong which are based on the Method of Difference ?*

A Inspite of the contrary opinion it must be said that laws proved by the M of Difference should be regarded as derivative, provided indeed that the requirements of the method have been strictly fulfilled, for we know that this method can establish causation, if its conditions are strictly complied with

102 Q. *What do you understood by a law of nature ? Distinguish primary and secondary laws, and explain and illustrate the different kinds of the latter. What do you understand by the expression that the world is a system of laws ?* (*I A* 10) *State exactly what you understand by a law and a law of nature How would you classify laws ? Mention the different methods of classifying secondary laws that have been adopted.* (*I A*, 19)

A **Different kinds of Secondary Laws** — Secondary laws may be classified according to different principles —

1 They are derivative and empirical (See above)

2. They are invariable and approximate An invariable law is that which holds good in *all* cases, and an approximate law is that which holds good in *most* cases Thus the law 'All bodies fall' is invariable, and the laws 'In most cases revolution begins in hunger,' 'Most cases of small pox are fatal,' are only approximate

3. Secondary laws may again be classified into—(A) those of succession, and (B) those of co existence

A. Secondary laws of succession may be subdivided into —(a) Laws of direct causation, *e g*, fire burns, water quenches thirst (b) Laws of remote causation, *e g.*, rats are the cause of famine (c) Laws of co effects of the same cause, *e g.*, spring follows winter, day follows night

B Laws of co-existence, may also be subdivided into several groups (see Uniformities of co existence, chap. (III).

The world is a system of Laws —This statement means not only that in the world there can be nothing but laws, but also that those laws are connected together so as to constitute a system. Hence it consists of two parts—

(1) The world is full of laws. The suspension of a law is

a miracle, but there is, as Hume observes, no room for miracles in the world. The suspension of the law of causation is chance, but chance has no existence We ascribe something to chance only when we are ignorant of its cause. Chance, therefore, has no real existence, but is due to our ignorance. All departments of nature are governed by laws. The principle of the uniformity of nature is universally true Cyclones, earthquakes, etc, are not exceptions to uniformity, as may commonly be supposed, for they have their own conditions, though hidden from a superficial view

(2) These laws are connected together so as to form a system Laws of a particular science are not isolated from one another, but there is a gradation of primary and derivative laws And though there are empirical laws which have not yet been brought under primary laws, there is a reasonable expectation that they will be gradually brought under them in the progress of sciences. It is indeed the aim of sciences to convert empirical laws into derivative ones, and many of them have already been so converted Viewed from a wider standpoint it can be seen that the laws of different sciences are interrelated. For example, biological phenomena are explained in terms of chemical laws, psychical phenomena are explained in terms of biological laws, and so forth The doctrine of conservation of energy, by showing that the various kinds of force (*e g.*, chemical, mechanical, thermal electrical, etc.) are mutually convertible, has established a close connexion among the laws of the various sciences, *e g*, physics, chemistry, etc Indeed, in course of the progress of sciences a time will come when all laws will be arranged in a hierarchy, the lower being proved to be deduced from the higher And when that time comes we shall clearly see that the world is a veritable system of laws

[For the rest see Q.Q. 98 and 100.]

103 Q *What are the respective uses of primary and secondary laws?*

A. The functions of primary and secondary laws are like the functions of the higher and lower officers of a government. The higher officers frame laws and the lower officers practically apply them So we see that the former have great *theoretical* value, and the latter great *practical* value. Indeed, it is the lower officers who come in contact with the people, remove their wants, and do them justice. Similar is the case with laws. Primary laws have great theoretical importance, as satisfying our understanding, but secondary laws have great practical value, as they are in touch with concrete reality The law of definite or multiple proportions is good, but only theoretically, as satisfying our longing for explanation of phenomena But the law that $H_2 + O = H_2 O$ (water) is of much practical use

104 Q *What are Axioms ?*

A Axioms are laws placed even above ultimate laws. They are characterised by simplicity, universality, and self-evidence Thus, the laws of thought, Aristotle's dictum, etc , are axioms Logic cannot prove them, but takes them for granted The line of demarkation between axioms and primary laws is not fixed by common consent The law of causation, for example, is taken by some to be an axiom, and by others as a primary or ultimate law [For axioms, see Chapter XVI]

105 Q *Secondary laws, esp. empirical ones, are of limited application Explain*

A Axioms are of universal application, *i e*, are not subject to the conditions of limited time and place Thus the Dictum, that, whatever is true of the whole distributively is true of the part holds good everywhere "But secondary laws are not so, being subject to the conditions of limited time and place" Take, for example, the law of the rise of water in an empty pump to the extent of 33 ft I cannot extend this law to any place I like It will be a mistake if I hold that this law holds good everywhere, say, on a high mountain It is true only in those places where similar conditions are present, where, for example, the pressure of the atmosphere is the same Thus the column of water must be less on the height of a mountain, because the [illegible] pressure is there less than on the sea-level. As for e[illegible] laws, we are even less sure of them, for we are quite in [illegible] dark as to their conditions Thus the law that scarlet flow[illegible] have no fragrance, I can by no means extend to an unkn[illegible] place with sufficient certainty Even in a neighbou[illegible] country it may not hold true [illegible]ence we should take [illegible] care in extending secondary laws, esp empirical ones, to unknown places

106 Q. *Menion different kinds of empirical laws*

✓ **A.** Bain mentions three kinds of empirical laws :— (1) Many of empirical laws are the results of the combination of primary laws under definite arrangements and collocations, *e g.*, the laws of wind and rain, Kepler's laws. (2) Some express relation between effects and remote causes, *e g*, the sowing of a seed ultimately followed by the growing of a big tree (3) Some are laws of co-existence or succession between the effects of the same cause, *e.g.*, the flow of the seasons, day and night.

107 Q *What are the characteristics of secondary laws, as compared with primary ones?*

A (1) The former are much more numerous than the latter There are only a few primary laws, which, by their permutation and combination, give rise to an indefinite number of secondary laws (2) The former are more complex than the latter (3) The former are of much practical use (being in touch with the concrete reality) , while the latter are of great theoretical value,

108 Q *Mill says that the ultimate laws of nature cannot possibly be less numerous than the distinguishable sensations and other feelings of our nature. Explain this.*

A The phenomena of nature are known through different senses, such as touch, vision, etc. No one of these senses in reducible to the other. We cannot reduce a colour to a sound, or a taste to a smell Hence there are at least as many ultimate laws as there are senses. Similarly, there are certain ultimate feelings, no one of which is reducible to another. We cannot, for example, reduce wonder to hatred, or pleasure to pain Hence there are at least as many ultimate laws in mind as there are ultimate feelings. Hence according to Mill, ultimate laws cannot be less numerous than ultimate sensations and feelings.

CHAPTER XI

EXPLANATION.

109 Q *What is an explanation? (I A, 14)*

A. To explain a thing means to make it plain or clear, and it is made clear, when our understanding is satisfied. But different people are satisfied in different ways What satisfies a rustic does not satisfy a scientist For example, a sudden outbreak of small-pox is explained to a common villager when it is said to be due the wrath of the goddess *Sitala* But a scientist will seek a different explanation Thus, explanation depends upon the degree of a man's understanding Broadly speaking, there are three classes of explanation, *viz*, metaphysical, scientific or logical, and popular [With the first we are not concerned The second and third are explained below]

110 Q. *Exhibit with illustrations the nature of logical (scientific) explanation (B. A, 02)*

A 'Scientific explanation' says C Reid, "consists in discovering, deducing, and assimilating the laws of phenomena." The rusting of iron is explained when it is assimilated to oxidation, that is to say, when it is shown that it is not a singular phenomenon, but is *similar* to other phenomena, such as combustion, etc which may be all brought under oxidation. Similarly, lightening was explained by Franklin by assimilating it with electricity. Or, we may explain a fact by deducing it from a law, and explain a lower law by deducing it from a higher law, as we explain the rise of water in a pump by deducing it from the law of atmospheric pressure When no law is known to exist, it is necessary to discover one, as the law of gravitation was discovered to account for the fall of bodies

From the above it is clear that the explanation of a fact or law means subsuming it under a law or a higher law. In the examples given above, rusting was explained by subsuming it under oxidation, and the rise of water was explained by subsuming it under the higher law of atmospheric pressure Explanation is thus *generalisation*, that is, pointing out the general case, of which the phenomenon in question is a particular application Now, as the causal law is the most important law, phenomena are said to be truly explained when they are subsumed under it, that is, when their causes are traced

⁂ **111 Q.** *What is meant by explanation in science? Describe and illustrate the different forms of scientific explanation Show how explanation is related to induction. (I A, 09) What modes of explanation are recognised in Logic? (B A, 00)*

A. [For the first part see above]

Mill mentions three different forms or modes of scientific explanation :—

(1) **Analysis**—A joint effect is explained when its seperate causes are found out. Thus, the rise of water in an empty pump is explained when it is resolved into its constituent causes, *e g*, atmospheric pressure and equal transmission of pressure by a liquid in all directions. A projectile is explained when its causes are traced, viz, the initial force, gravity, and the resistance of air.

(2) **Concatenation,** *i. e*, tracing the intermediate links. A remote effect is explained when the intermediate causes are discovered 'Cats save us from famine' is explained when it is shown how they do so by destroying the rats which are so harmful to growing crops Again, 'the normal degree of rain is the cause of good harvest' is explained by showing how it does so by fertilising the soil without causing flood

(3) **Subsumption.** A lower law is explained by subsuming is under a high law Thus, the fall of bodies is explained by subsuming it under gravity, combustion is explained by subsuming it under oxidation, and so forth.

N. B.—Of the above three forms subsumption is the fundamental one, the other two being derived from it. When a joint effect, *e. g.* a projectile, is resolved back into its component causes, each of the latter is more general than the former, which may, therefore, be said to be subsumed under it. Again, in concatenation, when an effect is traced link by link to a remote cause, each of the preceding links is more general than the succeeding one, and hence the process may be viewed as consisting in subsuming the latter under the the former. Thus, the existence of cats is more general than the destruction of rats, for cats may exist without destroying rats. Again, rats may be destroyed, yet famine may be caused, and therefore, the destruction of rats is more general than famine. Hence, we see that all the various forms of explanation, in the last resort, consist in subsuming or classifying the lower under the higher This shows the vitally close relation of explanation to classification.

Relation of Explantion to Induction —Explanation is generalisation, and induction gives rules for valid generalisation Again, to explain a phenomenon means to trace its cause, and it is the function of induction to prove or discover a cause. Hence, induction is a means to explanation. Explanation is our goal, and induction is a stepping-stone to that

**** 112 Q.** *Contrast the scientific conception of explanation with the popular What is the relation of hypothesis to explanation?* (*I A*, 14)

A The following are the points of distinction between the scientific and the popular explanation —(1) Popular explanation is satisfied with finding out superficial points of resemblance, but scientific explanation traces the deep-seated points of resemblance. (2) Popular explanation often traces effects to supernatural causes, but sc explanation, to natural causes Thus rain is popularly explained as the sprinkling of water by the *Airavata*, diseases by the wrath of particular goddesses, and so forth. (3) Popular explanation often commits the fallacy of *post hoc ergo propter hoc* (*After* this, therefore *on account of* this). Thus if a comet appears just before the fall of a monarch, people will regard its appearance as the cause of his fall. (4) Popular explanation is usually concerned with a particular fact, while scientific explanation with a class of facts Sc. explanation is concerned with discovering causes of murder, cholera, etc, *in general*, and not of the murder, cholera, etc., of this or that individual.

Relation of Hypothesis to Explanation :—

Explanation of a fact is to trace its cause, and of a law is to subsume it under a higher law But sometimes the cause or the higher law is not known In such a case it is necessary to frame a hypothesis as to the probable cause or law, and prove it inductively or deductively Indeed, it is for the sole purpose of explaining phenomena that hypotheses are framed The undulatory theory, the atomic theory, the heleocentric theory, etc , were hypotheses framed simply to explain phenomena in different departments of nature

113 Q. *When is a fact explained? How does hypothesis lead on to explanation?* (*B. A.*, 06).

A, (See above)

* 114 Q. *What are the limits to explanation?* (*I. A*, 14).

A. Explanation being subsumption and assimilation, limits to them are necessarily limits to explanation Hence the following cannot be explained :—(1) Elementary sensations and feelings, *e. g*, colour, taste, smell, pleasure, pain, etc , for they have nothing like them with which they may be assimilated. (2) Axioms, because they cannot be subsumed under anything higher, being themselves the highest generalities. (3) The individual peculiarities of objects, as they have nothing like them with which they may be assimilated (4) The ultimate properties of matter, *e g*, extension, impenetrability, as they are incapable of subsumption

115. Q. *Illustrate some of the commoner types of fallacious explanation* . (*B. A.*, 98),

A. (1) 'One form of fallacious explanation is to repeat the fact in different language, as when the fact that opium causes sleep is explained by saying that it has a soporific virtue, or as when the fact that the future resembles the past is explained by saying that nature is uniform.

(2) Another form of false explanation consists in supposing something to be the cause which is but an accidental antecedent, as when the fall of an empire is explained by the appearance of a comet.

(3) A third form of fallacious explanation is to attempt to explain a primary law, such as the law of gravitation

116 Q *What is scientific explanation? State and explain its different forms. What are the limits of explanation? Explain and illustrate the chief varieties of fallacious explanation* (*I A*, 16) *Define the nature, and limits of sc explanation* (*B A.*, 97) *Explain the nature, modes, and limits of sc explanation* (*B A*, 06). *What is sc explanation? What* *are its different forms? Explain and illustrate each of these forms What are the limits of explanation?* (*I A*, 19) *Discuss what is meant by scientific explanation, and show the relation between explanation and classification* (*I A*., 20) *Distinguish between popular and scientific explanatian Indicate the different forms of the latter Are there any limits to explanation?* (*I A*, 21)

A [See above]

117 Q *How is sc explanation related to induction and deduction?* (*B A*, 07)

A [For its relation to induction, see Q III.]

The relation of Explanation to Deduction.—Explanation may assume the form of subsuming a lower law under the higher, in which form it is akin to induction, or it may assume the form of *deducing* a lower law from the higher, in which form it is akin to deduction We know that in cases of intermixture of effects direct induction fails, and that our only recourse there is the deductive method, from which it follows that for explaining a complex (intermixed) effect deduction is indispensably necessary

CHAPTER XII.

HYPOTHESIS

✓ *118. Q. *What is meant by hypothesis in science? What different kinds of hypothesis are there? Give examples. Explain how hypotheses contribute to scientific discovery, citing instances. Explain the relation of hypothesis to induction* (*I A*, 09). *What are the circumstances favourable to Discovery? What are the different forms of hypothesis?* (*I A*, 18)

A Hypothesis defined :—A hypothesis is defined by Mill thus :—"A hypothesis is any supposition which we make (either without actual evidence, or on evidence avowedly insufficient) in order to endeavour to deduce from it conclusions in accordance with facts which are known to be real, under the idea that if the conclusions to which the hypothesis leads are known truths, the hypothesis itself either must be, or at least is likely to be, true." Analysing this definition we can see that (1) A hypothesis is a supposition or guesswork (2) Being a guesswork, it is necessarily made either without any sort of evidence or on insufficient evidence, for a guesswork cannot obviously be made on sufficient evidence. (3) The purpose of this supposition is to explain known facts (4) If a hypothesis succeeds in accounting for facts, then it is most probably true, though it cannot be said that it must be true, for wrong hypotheses, too, are known to explain facts

Forms of Hypothesis :—A hypothesis is a supposition A supposition must be regarding *something* The question is what this something is Now, this something may be an agent, or the mode of operation of an agent, or the collocation of agents Accordingly, there are three forms of hypothesis A hypothesis may be regarding—(1) An agent or cause. Sometimes the mode of operation of an agent or cause is known, and we are to hypothesise about the agent or cause itself. Such is the hypothesis about Neptune, where the mode of operation, *viz* the law of gravitation, is known Such again is the hypothesis about a thief or murderer in a particular case of theft or murder. (2) Mode of operation of an agent.

Sometimes the agent is known, and we are to hypothesise about its mode of action, *i e*, the law to which it is subjected Such is the hypothesis of gravitation, where the agent, *viz* the earth, is known, and the hypothesis is about the law of its attraction. Such again is the hypothesis about sound, where the agent, *viz*, air, is known, and the hypothesis is about the mode of its acting upon the membrane of the ear (3) Collocation, *i.e*, the arrangement of materials, or the circumstances under which something happens Such is the geocentric or the heleocentric hypothesis about the collocation of the heavenly bodies, such as the sun, the earth, etc., such again is the hypothesis regarding the circumstances under which a case of theft or murder occurs

N B—Sometimes it is necessary to suppose both an agent and its mode of operation, as in the case of light, where we suppose both ether and its mode of operation.

Relation of Hypothesis to Induction:—The main function of induction is to establish the causal relation Now, whenever we are to ascertain the cause of a phenomenon, we must start with a hypothesis regarding the probable cause, and then try to prove it by the Exp. Methods. When a hypothesis is thus proved it is exalted to the rank of an induction Hence an induction is a proved hypothesis, (and a hypothesis is a preliminary step to induction)

From the above account we can see how a hypothesis leads to scientific discovery. For example, a physician who is intent upon discovering the cause of war fever cannot proceed at random He must frame a hypothesis regarding its probable cause, and test it in the light of the experimental or deductive methods Indeed, discovery means framing hypothesis after hypothesis till the right one is hit upon Hence we see that those logicians, *e g.*, Whewell, according to whom Logic is a science of *discovery*, attach great importance to hypothesis, whereas those, *e g*, Mill, according to whom Logic is merely a science of *proof*, undervalue hypothesis, because proof supposes already existing hypotheses, with the framing of which Logic is not at all concerned

Circumstances favourable to Discovery:—The following are some of the circumstances which help discovery by helping the formulation of hypothesis;—(1) "Examination of a very large number of similar cases," which is expected to suggest the common features (2) "Examination of a few cases with care and attention." (3) "Examination of comparatively simple or uncomplicated cases. Such cases would readily suggest the points of similarity palpably present in them" (4) Deductive reasoning, both immediate and mediate. 'Thus, by simple conversion of the proposition 'All material bodies have weight,' we may be led to suppose that perhaps 'All bodies having weight are material." Such a conjecture may subsequently be put to test, and then accepted or rejected. (5) The M. of C Variations, especially the extreme cases of this method, "If, for example, intense heat aggravates a disease very much, while feeble heat is attended with slight aggravation, then the cause of aggravation is very easily detected (6) Analogy [As for how analogy leads to discovery see Q. 97].

✓ 119 Q. *Do hypotheses assist observation in any way? If so, how? What are the other uses of hypotheses? Distinguish between a working hypothesis and a descriptive hypothesis.* (*1 A*, 19)

A. It goes without saying that hypotheses are a great aid to observation They serve to regulate the process of observation When we are to determine the cause of a particular phenomenon, we are at a loss to ascertain which facts to observe, and which not, unless we proceed by framing a hypothesis as to the probable cause

(For the other uses of hypothesis see Q 131, and as for the distinction between working and descriptive hypotheses see QQ 121 & 127)

120 Q. *Newton wrote 'Hypotheses non fingo.' Can this be reconciled with the view that the first step in the inductive process is necessarily a hypothesis?* (*B. A. H., 04*)

A When Newton said 'Hypotheses non fingo' (I do not make hypotheses), he did not really mean that all hypotheses were useless By saying this he only protested against the random and extravagant hypotheses, which are so common in all ages Indeed, he himself framed different hypotheses, *e g*, the hypothesis of gravitation and the undulatory theory His assertion is not, therefore, inconsistent with the view that the first step in induction is a hypothesis.

✓ 121 Q. *What is a hypothesis? What are the characteristics of a legitimate hypothesis? How does a legitimate* *hypothesis differ from a scientific induction? Give illustrations. What is meant by a working hypothesis?* (*I. A.*, 10) *Describe the conditions of a legitimate hypothesis* (*I A.*, 20). *Explain and illustrate.—Working hypothesis* (*I. A*, 21)

A. The following are the characteristics, marks, or conditions of a legitimate hypothesis :—(1) It must be *verifiable* and *definite* There are hypotheses which are so vague as not to admit either of proof or disproof Such hypotheses are useless A hypothesis must be so clearly and definitely stated as to be capable of either proof or disproof (2) If the hypothesis be regarding an agent, the agent must be a *vera causa*, a real cause The disappearance of a thing from a room, for example, must not be supposed to be due to a mischievous spirit, for a spirit is not a real cause The term *vera cause* must not be taken in a strict sense so as to mean only a cause which is *actually* known to exist, for in that case an atom or ether cannot be said to be a vera causa, because it is not actually known to exist Therefore, the term should be understood in a liberal sense so as to mean a cause which may *possibly* exist, *i.e.*, whose existence is not inconsistent with possible experience C. Read defines *vera causa* as 'a condition whose existence may be proved independently of the phenomena it was intended to explain' (3) It must be adequate to explain the facts which it proposes to explain If it fails to do so, then it must be either discarded or modified (4) It must not be inconsistent with the established laws of nature The old hypothesis of phlogiston, for example, is illegitimate, because it contradicts the law of gravitation

Legitimate Hypothesis and Valid (scientific) Induction.—A hypothesis is regarded as legitimate when it is definite, verifiable, adequate, and consistant with the known laws of nature But it is not yet *proved*, from many hypotheses *e g*, the geocentric hypothesis of Tolemy, fulfilled the above conditions, but have since been found to be false Hence Mill rightly demands further and stricter proof of a hypothesis, *viz.*, by the Expl Methods and by strict deduction And it is only when a hypothesis is so proved that it is elevated to the rank of a scientific induction Hence the difference between the two is that the one is only highly probable, but the other is practically certain.

✓ **Working Hypothesis :**—When a hypothesis has not yet conformed to the conditions of a legitimate hypothesis, and is consequently less probable than the latter, it is called a working hypothesis A working hypothesis is thus one which is provisionally accepted as true, and which for the time being accounts for facts, but is not yet established by the conditions of a legitimate hypothesis It waits to be converted into a legitimate hypothesis, or to be rejected if found unsatisfactory When a working hypothesis is found unsatisfactory, a better hypothesis is substituted. For example, when the geocentric hypothesis was found unsatisfactory, it was replaced by the heleocentric hypothesis Thus we see that a working hypothesis has got its own value For the time being at least it accounts for facts, and it paves the way for a better hypothesis Even when rejected, it is sometimes retained as a convenient mode of describing phenomena. When a working hypothesis has satisfied the conditions of a legitimate hypothesis, it becomes an established hypothesis.

[As for the conditions of the proof of a hypothesis see Q. 125].

✓122 Q *What is a hypothesis? Give an example from common life Explain the use of hypothesis What are the conditions of a good (legitimate) hypothesis?* (*I A*, 13)

A [See above For the uses of hypotheses see Q 131.]

In our daily life we often frame hypotheses When a book disappears from my room, or when somebody is murdered we frame a hypothesis regarding the probable cause of the disappearance of the book or of the murder of the man, and direct our investigation accordingly. When an expected letter does not arrive, when I do not feel well, and in all similar cases, I frame hypotheses as to the probable causes.

.*. 123 Q *Distinguish between a theory and a hypothesis. Give the canons (rules, conditions) to which a good (legitimate) hypothesis must conform, and illustrate them. Explain the functions of hypothesis in induction.* (*I A.*, 16) *What do you understand by theory?* (*I. A.*, 19)

A Hypothesis and Theory :—There is no sharp line o demarkation between a hypothesis and a theory. A hypothesis, when proved. is called an induction or law Before i is proved to be a law; somewhere, when it has received som confirmation, it is called a theory But there is a differenc of opinion as to when a hypothesis passes into a theory. Th undulatory theory of light is even now called by some undula tory hypothesis Thus we see that the distinction between them is not clear.

(For the remaining parts of the question, see above).

124 Q. *What tests have been suggested of a valid hypothesis? Are such tests really required? Show by recorded examples the value of descriptive or working hypothesis.* (*B. A*, 04)

A Surely such tests are necessary, for if a hypothesis does not conform to such conditions, it remains only as a working hypothesis, waiting to be rejected, when found unsatisfactory

(For the rest see Q 125)

. 125 Q *Explain the use of hypothesis in scientific investigations Given a verifiable hypothesis, what constitutes its proof or disproof? Distinguish between a working hypothesis and an established hypothesis* (*I A.*, 14) *What constitutes a valid induction? Distinguish it from a legitimate hypothesis* (*I. A*, 15) *What seems to you a satisfactory proof of a hypothesis?* (*I A*, 20).

A. When a verifiable hypothesis is proved, it becomes a valid induction. It is proved in the following ways –

1 If the hypothesis be regarding an agent, and the agent be capable of being observed, then it must be actually observed Thus, the hypothesis regarding Neptune was proved by actually observing it But if it be not capable of being observed, then some other evidence of its existence must be found out than the facts which it proposes to explain Thus the existence of ether was proved by the retardation of the motion of the heavenly bodies, 'as shown especially by the history of Enche's comet'.

2. It must be shown to account fully for the facts which it proposes to explain. If it fails to do so, then it must be either discarded or modified.

3 It must be shown to be consistent with the known laws of nature, 'and, if not itself of the highest generality, must be derivable from primary laws.' The old hypothesis of phlogiston is now rejected, as it contradicts the law of gravitation

4 It must be able to predict future events, where it is of such a nature. Prediction is regarded by Whewell as a

strong mark of the truth of a hypothesis, But Mill differs from him on the ground that many false hypothesis, *e. g.*, Ptolemy's geocentric hypothesis, also could correctly predict phenomena, such as eclipses

5 If possible, it should be shown to 'agree with distinct inductions concerning different classes of facts.' This is what is called by Whewell consiliense of inductions, Consilience means agreement Hence consilience of inductions means that various inductions (*i. e.*, empirical laws in different spheres agreeing together in being explained by the same hypothesis Thus Newton's hypothesis (now called law) of gravitation, framed to explain the fall of bodies, received confirmation when it was found to explain also laws in other departments, such as the orbits of planets and their satellites, tides, etc

6 It must be shown to be the only possible hypothesis by excluding all the rival hypotheses. This is the strictest condition, and if it is fulfilled, then the hypothesis is unquestionably proved Sometimes it is seen that different hypotheses equally account for the same facts. Thus in Astronomy, both the heleocentric and geocentric hypotheses equally explain the heavenly phenomena. In such a case if I fail to exclude the rival hypotheses, then my hypothesis cannot be said to be proved And such exclusion can be effected by what was called by Bacon *Experimentum crusis* (crucial experiment)

⁂ 126 Q *What do you understand by crucial experiment* (*I A*, 19) *and crucial instance? Explain and illustrate crucial experiment* (*I A*, 21)

A These terms were used by Bacon A crucial instance (instantia crucis) is one which decides between rival hypotheses, *i e*, shows decisively which of them is true by excluding others If a crucial instance is got, not by observation, but by experiment, we call this experiment crucial experiment (experimentum crucis) Thus, the *principle of interference* was a crucial instance in favour of the undulatory, theory, as against the older corpuscular theory,

⁂ 127 Q *What do you mean by a representative Fiction* (*Descriptive Hypothesis*)?

A. "Some hypotheses consist of assumptions as to the minute structure and operation of bodies. From the nature of the case, these assumptions can never be proved by direct means Their only merit is their suitability to express (*i. e* describe) the phenomena They are Representative Fictions' (Bain) Thus, the hypothesis of atoms cannot be proved by direct means But it suitably describes the various phenomena of bodies, *e g*, chemical combination, expantion by heat Similar is the case with the hypothesis of ether, which suitably describes the facts of light Such hypotheses are called Descriptive Hypotheses

128 Q *Distinguish between a fact and a theory*

A The term fact is ambiguous Sometimes it means an individual object (*e g* Ram, a particular table) or event (*e. g* Ram's arrival in Calcutta), which is capable of perception. In this sense, a fact is *concrete* and *individual*, while a theory is *abstract* and *general*. Sometimes *fact* implies a lower law, and *theory*, a higher law. Thus the fall of body is called a fact, and gravitation is called a theory. In this sense, a fact is a lower law subsumed under a higher one, which is called theory. Hence the relation is that of species and genus √

129 Q *Distinguish between a Hypothesis and an Abstraction Is Geometry hypothetical* ?

A Dugald Stuart understands the term *hypothesis* in the sense of abstraction Thus, according to him, Euclid's *line*, *point*, etc , are hypothetical, because they do not exist in reality *Line* is that which has *length*, but no *breadth* , but such a thing cannot actually exist.

But, to say that lines, etc., are hypothetical is to use the term hypothesis in a wrong sense, *viz*, in the sense of *abstraction*, for geometrical lines, etc , are but abstractions of our mind Hypothesis and abstraction resemble each other in this that both of them are *representations* of our mind. But there are important points of difference A hypothesis is a guess-work regarding something unknown , but an abstraction is not so. Again, the consequences following from a true hypothesis tally with facts, but the conclusions deduced from an abstraction do not correspond to reality, but are only ideally true. Hence Geometry is not a hypothetical science, but an abstract science

√130 Q *Are uniformity of Nature and Law of causation mere hypotheses ? Are all sciences hypothetical* ?

A C. Read protests against the uniformity of nature and the law of causation being called hypotheses. They are, he says, the 'Universal Postulates' But such a protest is vain and empty from an empirical standpoint (and the empirical standpoint is generally accepted by the modern scientists and logicians). That 'nature is uniform in her processes' and that 'all phenomena are caused', are undoubtedly *suppositions* And according to Mill, Bain, and other empiricists, these suppositions are proved only by Induction per Simple Enumeration Hence they can be at best regarded as legitimate hypotheses, but not *laws*, far less *postulates* Viewed from the rationalistic or intuitional standpoint, they are no doubt postulates. Now if they are only hypotheses, as they undoubtedly are from the empirical standpoint, then because the laws of different sciences are based upon them, these sciences must needs be hypothetical also Hence we conclude that from the empirical point of view, all sciences are hypothetical , but from the intuitional of rationalistic standpoint, as that of Reid or Kant, sciences are not hypothetical.

V ⁂ **131 Q** *What are the uses of Hypotheses ?*

A Doubts may arise as to the utility of hypotheses in view of the strong protest from such a great scientist as Newton ('Hypotheses non fingo'). But doubts are dissipated when we remember that Newton's protest was made against random and extravagant hypotheses. Hypotheses mark the starting-point of all inductive investigations. Whether we regard Logic as a science of discovery or of proof, hypothesis is essentially necessary in each case Proof supposes pre existent hypotheses, and discovery supposes both formulating and proving a hypothesis In each case hypothesis constitutes the preliminary step of induction. Even when a hypothesis is incapable of proof it serves to unify knowledge by connecting together particular facts and law. As for descriptive hypotheses, they serve the purpose of suitably expressing the phenomena which are incapable of being perceived. [As for the use of working hypotheses, see Q. 121]

CHAPTER XIII.

CLASSIFICATION

***** 132 Q** *Exhibit the nature and use of classification* (*B.A*, 09)

A. 'Classification', as defined by C. Read, 'is a mental grouping of facts or phenomena according to their resemblances and differences, so as to serve some purpose.' The definition is thus analysed :—(1) Classification is a *grouping* of individual objects (2) The grouping is a *mental* or *ideal* one When, for example, a botanist classifies the plants, all the plants of the earth are not evidently present before him. He has, therefore, to classify them in his mind, *i e.*, ideally (3) Objects are grouped according to their *resemblances* and *differences*. Those resembling one another are grouped in a separate class (4) The grouping is made *for some purpose* The purpose may be either general or scientific, as in the classification of a botanist or a zoologist, or it may be special or practical, as when a gardener classifies the plants of his garden.

Uses of Classification :—Classification helps memory It is impossible to remember all the objects of the universe But we can remember a comparatively small number of groups, and refer individual objects to their respective groups (2) Inferences (except analogical) are impossible without classification Induction proceeds from individuals to classes, or from lower to higher classes ; and in deduction we proceed in the reverse order Hence both suppose classification (3) Classification facilitates reference, and thereby helps the understanding. We may imagine the difficulty of finding out a particular word in a dictionary, if the words are not classified there

133 Q *Explain and illustrate the bearing of classification on generalisation.* (*B. A*, 03, 09)

A Classification is a mode of generalisation. When animals are classified into vartebrate and invertebrate, these properties are generalised over the individuals denoted by them. A class is more general than each of the indivinals placed under it, from which it follows that the process of classification is an act of generalisation.

134 Q *What is meant by a natural kind or class?* (*I.A*, 09)

A. The term *natural* or *real* kind is used by Mill simply to denote a class which we find in nature, as opposed to a class which is artificially formed. Thus the cow, the horse, the flower, gold, water, and the like are natural kinds A natural kind may be defined as a class, the objects, included in which resemble one another in a large and indefinite number of important properties. Hence 'the horse' is a natural kind, because all horses resemble one another in a large number of important attributes But if we classify animals into *big* and *small*, the class *big* (or *small*) *animal* is not a natural kind, because the animals included in the class *big animal* resemble one another only in a few unimportant points, such as bulk, weight, and a few others

N B,—The doctrine of natural kind is based upon the old doctrine of *special creation*, which is that God originally created separately all these existing species, such as cow, horse, water, etc. But this old doctrine has been challenged by the modern theory of evolution, according to which the different species were not separately created by God, but have gradually evolved out of a few original stocks.

⁂ **135 Q** *Give an account of natural classification, explaining what is meant by 'essential.' 'fundamental' characters as bases of classification "A class is nothing but the objects, contained under it." Examine this statement of Mill, showing whether it is correct or not* (*I A.*, 19) *What is natural classification?* (*I.A.*, 18)

A. Natural, scientific, or philosophical classification, as opposed to artificial or technical classification, is that based upon fundamental or essential points of similarity and difference A natural class is that which includes objects resembling one another, and differing from the objects of another natural class, in essential characters or qualities. A quality is regarded as essential, if it is (1) persistent, and (2) connected with many other attributes, as being their effect or cause Thus the classification of animals into rational and non-rational is a natural classification, for rationality is an essential attribute, because it is (1) persistent in all rational creatures, and (2) deeply connected with the various other properties, such as the nervous system, wisdom, intelligence, justice, benevolence, etc But an artificial classification, such as the classification of animals into big and small, is based upon an unimportant character, because bigness is an accident only Linnæan system of classification according to the number of stamens and pistils is an instance of artificial classification A classification of objects into what Mill calls natural kinds is thus a natural classification, because the objects of a natural kind resemble one another in many and important characters

N B—According to some, natural classification is that made by nature, and artificial classification is that made by men But this statement is not correct; for in all classifications whether natural or artificial, resemblances and differences are *made* by nature, and *found* by man. In the above instance of artificial classification, *viz*, that into big and small animals, the distinction between big and small has not been made by man, but only found by him Hence, as Venn observes, the real distinction is that while the so-called natural classification is made for some *general* purpose, *viz*, knowledge, the so-called artificial classification is made for a *special* purpose, and so any superficial attribute that will serve the purpose of the classifier may be selected as the basis of artificial classification Hence natural classification and artificial classification should respectively be called classification for general or scientific purposes, and classification for special or practical purposes.

'A class . . under it' (Mill):—This view is based upon nominalism, according to which individuals alone exist in the real world—there is no identity of essence underlying individuals, they only resemble one another in certain common attributes All classification and reasoning are based upon similarity in respect of common attributes, and not upon the identity of essence But such reasoning is obviously precarious, for the true connection of one attribute with others cannot be discovered by experience Hence the realistic view seems to be the correct one, as supplying a sure basis for inference and its auxiliary processes, such as classification

** **136 Q** *Show the relation of classification to definition What is a classification by series? Illustrate it in applying the method of concomitant variations in demonstrating* *a concomitance of mental and cerebral complexity in the animal kingdom* (*B.A.*, 08) *Explain and illustrate :—Classification by series* (*I A*, 21).

A. Classification and Definition :—Scientific classification is based upon fundamental points of resemblance. Therefore, in classifying objects we are to proceed by discovering these essential points of resemblance, and this is definition. Thus scientific classification proceeds upon definition [As artifical classification is based upon resemblance in accidental properties, it has nothing to do with definition] Again, definition presupposes classification, for we do not define an individual, but a class Hence the relation is that of interdependence.

Classification by Series :—In ordinary classification we proceed upon the presence and absence of an attribute, as in classifying animals into rational and non-rational, or into vertebrate and invertebrate. But sometimes it is the case that we are to classify objects according to a principle which is present in all the objects, but in varying degrees Suppose I am to classify all conscious beings, and I take the possession of brain as the principle of classification I cannot evidently classify the conscious beings into (1) those possessing brain, and (2) those not possessing it, for all conscious beings possess it But one thing I can do , I can arrange these animals in a hierarchy according to the complexity of the brain, beginning at the top of the series with the class of beings whose brain is most complex, and ending at the bottom with the class of beings whose brain is least complex Such a classification is called classification by series Thus we see that a serial classification is applicable where an attribute (*e.g*, possessing a brain) is illustrated in various degrees in the individuals to be classified

A classification by series is a good field for applying the M. of Concomitant Variations In the above example, when the classes have been arranged in a higher-and lower order, I may easily mark that the animals placed at the top of the hierarchy possessing the most complex brain show signs of the highest order of intellect, and as I come down the series, less and less intellectual development is manifested This gives me a case for applying the M. of C. Variations so as to discover a connection between mental and cerebral development.

⁂ **137 Q** *Explain the nature of classification and division, showing how they are related to each other Point out the principal errors incidental to each Distinguish between division and classification* (*I. A* , 17).

A. [As for the nature and errors of classification, see questions 132 and 175 respectively ; and as for those of division see Deductive Logic.]

Relation of classification to Division.—The relation of division and classification is the same as that between deduction and induction In division we begin at the top, and proceed downwards gradually, until we reach down the *infima species* , while in classification we begin at the bottom with the individuals, and proceed higher, forming more and more general groups Division is *analytic*, because it separates a higher group into a number of smaller ones ; while classification is *synthetic*, because it combines the lower groups into the higher Division is *formal*, while classification is *material* Hence divison is called deductive classification by some, *e g*, C Read. they both aim at the unificati of nature

138 Q. *Exhibit the procedure in natural classification* (*B A* , 01) *State the rules of classification*

A The following is the procedure of classification :—

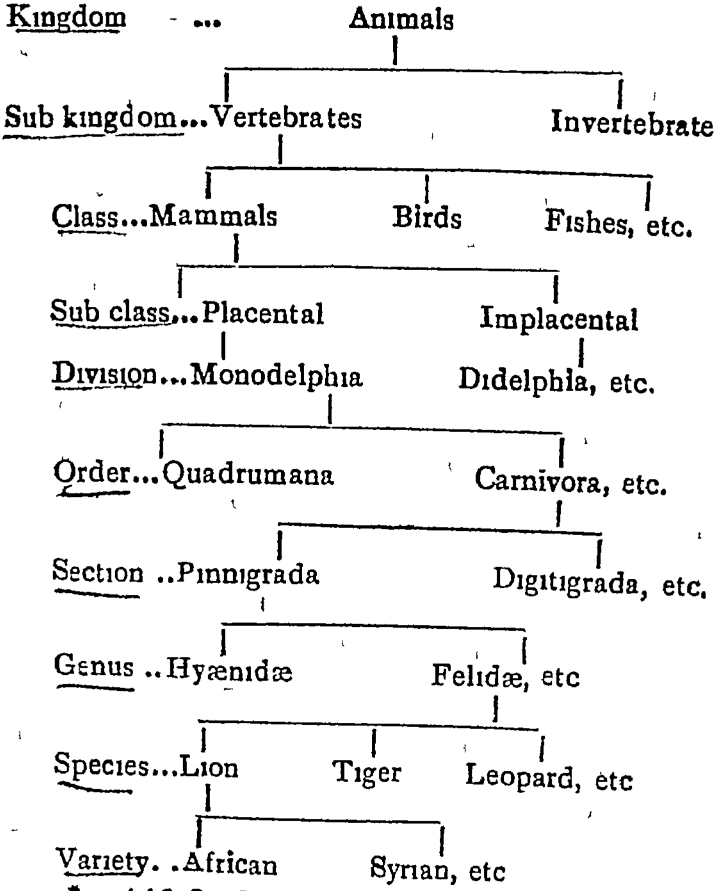
1 *Place together in groups (or in thought) those things which possess in common the most numerous and the most important qualities* This is called by Bain the golden rule of classification In this way various small groups will be formed, *e g*, the lion, the tiger, etc

2 *Connect those groups which have greater resemblance or affinity, and separate those groups which have greater difference* Thus the groups of the lion, the tiger, the puma, etc , being connected together, will form the higher group Felidœ This rule is called the *rule of classification by series*

3 *Graduate the classification upwards* The lower groups are to be placed under the higher, which in their turn under the still higher group, and so on, until we reach the highest group

139 Q *Explain the sense of the terms :—Family, kingdom, species, variety, order, genus, as used in classification, and show their respective places in the scale of natural classification, giving examples of each* (*I. A.*, 11).

A In natural classification, groups are arranged in a hierarchy. Several classes of this hierarchy have got their special names, denoting their respective places in the scale. The term *kingdom* denotes the highest class, *species* the last class but one, *variety* the last, *order* the sixth, *genus* the last but two. The adjoining table will show their respective places (the table is not exhaustive). The classification is that of animals :—


Kingdom ... Animals
Sub kingdom... Vertebrates
Invertebrates
Class... Mammals
Birds
Fishes, etc.
Sub class... Placental
Implacental
Division... Monodelphia
Didelphia, etc.
Order... Quadrumana
Carnivora, etc.
Section .. Pinnigrada
Digitigrada, etc.
Genus .. Hyænidæ
Felidæ, etc
Species... Lion
Tiger
Leopard, etc
Variety. . African
Syrian, etc

*** 140 Q *Is classification based on type or on definition?* (*I A*, 17) *Is a natural group determined by a type or by a definition? Discuss this question* (*I A*, 18)

A Whewell holds that classification is made by type, and not by definition. A type is an eminent example of a class, *i e.*, an example which possesses the characteristics of the class most conspicuously Shakespeare, for example, may be regarded as the type of the Elizabethan poets Now, Whewell says that in classification, we first select a few types, and then group objects round each type according to their degree of *general* resemblance to it In forming the class *felidæ* I may, for example, take *tiger* to be the type, and group round it other animals, such as lions, leopards,etc, superficially resembling it.

In opposition to Whewell, Mill says that classification is determined not by type, but by definition Whewell's classification is precarious, as it is based upon vague and superficial resemblance to a type. In scientific classification we must proceed by enumerating the important characteristics, *i e*, by definition, and grouping objects according as they possess or do not possess those characters Yet, says Mill, Whewell's theory has got some value Suppose I am to classify 100 objects I select the properties *a, b, c, d,* for one group, and *x, y, z,* for another group 50 objects possess *a, b, c, d,* and 40 possess *x, y, z,* but 10 possess *a, b, x, y,* Under which class am I to place these last ten (which are said to be marginal instances, being on the marginal line between two groups) ? Here the type is necessary They will be classified according as they *generally* resemble this type or that Thus the marginal instances require type for classification Besides, a type, being a striking example, often *suggests* a class. Whenever we see an object, we automatically refer it to a type But whether it really belongs to the class denoted by the type is to be determined by definition, *i e*, by finding whether the resemblance is superficial or in respect of important properties.

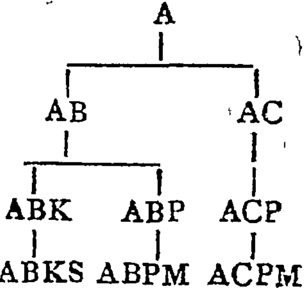
We may, therefore, conclude that Whewell's theory is a popular one, for in practical life we form classes by type But Mill's theory is scientific, because we ought to clssify objects by definition In fact, classification is *suggested* by type, but *determined* by definition. The marginial instances are no doubt classified by reference to a type.

141 Q *How has the doctrine of Evolution modified scientific classification ?*

A. According to the theory of evolution, the various species have gradually evolved out of a common stock. These species are not fixed, as supposed by the old doctrine of special creation, but are changing. This doctrine has modified scientific classification in the following ways :—

(a) It shows that classes are not fixed for ever, but are changing The classes of to-day may not all exist a thousand years hence.

(b) According to this theory, classification is based upon the *nearness of kinship*, and not upon the degree of resemblance, as will be clear from the adjoining table. ABPM resembles ACPM more than it resembles ABKS Yet ABKS and ABPM should be placed together, as being nearer in decent from the parent stock.



(c) From the above it is obvious that according to this theory, classification becomes *deductive,* for we classify objects according to their *decent from* common stocks.

142 Q *What are the limits to scientific classification* ?

A (1) Classification being a grouping of the lower classes into the higher, it follows that a *sumum genus* cannot be classified, as there is nothing higher than it.

(2) The marginal instances, *e g*, sponge, arsonic, etc, cannot be scientifically classified, because they possess the characteristics of each of two different classes, between which they lie.

(3) Certain composite substances, *e g.*, granite, cannot be classified owing to their irregular composition.

CHAPTER XIV.

DEFINITION.

⁂ 143 Q *Exhibit the nature and use of definition* (*B A*, 00).

A. **Nature of Definition** :—Definition is said to be the *statement* of the connotation of a term, or of the fundamental characteristics of a class of objects Definition, viewed thus, is merely formal It ignores the essential part of the task It consists in the bare statement of the essential properties of a class without taking into account how these properties are ascertained To ascertain these properties is surely far more important than barely to state them Definition, viewed materially, is the *process* whereby the fundamental properties of a class of objects are ascertained.

Use of Definition :—Inferences consist of propositions, and propositions of terms. Terms are thus the ultimate constituents of inferences Hence, if the meanings of terms are not rendered clear by definition—if terms are allowed to remain ambiguous, then our inferences must necessarily be confused and fallacious Again, the ambiguity of terms has been the fruitful source of many a fruitless controversy, such as that of the freedom of will. Hence definition not only secures correctness of inferences, but also secures us against many a useless dispute, which have in a large measure retarded the progress of philosophy.

⁂ 144 Q. *Indicate the formal and material conditions (rules) of Definition.* (*I*, *A*, 17).

A. Material conditions are the rules of procedure necessary to ascertain the connotation of a term. They are as follows —

1 "Assemble for comparison the particulars coming under the notion to be defined," (Positive rule)

2 "Assemble for comparison the particulars of the opposed or contrasting notion" (Negative rule)

3. Select only the common and fundamental properties,

Suppose I am to define *food* For this purpose it is necessary to compare the articles commonly called food It is not indeed possible to collect for comparison all such articles The *representative* or typical articles, *e g*, rice, bread, meat, fish, vegetables, and the like, will be enough for our purpose Having compared them we find that they all possess in common the essential property of nourishing our body But in order to have an adequate idea of *what food is*, we must understand *what it is not* For this purpose we must examine those articles which are not food, but are liable to be confounded with food, such as tea, alcohol, etc , and we shall find that they do not nourish our system Hence we define food as an article which nourishes our body

[As for the formal rules, see Deductive Logic].

145 Q. *What is definition, and what is its use ? Mention the difficulties that occur in the process, and show how they are to be met, giving concrete examples.* (*I A*, 14).

A , [For the first half, see above.]

Difficulties involved in the process of Definition :—(1) It is not possible to assemble for comparison all the instances, nor even the representative or typical instances, which are too numerous (2) There are marginal instances which possess certain characteristics of one class, and certain others of another Hence they baffle all attempts to define them (3) It is often a task of immense difficulty to ascertain which attributes are essential or fundamental, and which are not.

Remedy suggested :—To remove these difficulties, *definition by type* is suggested by some It is impossible they say, to examine all the instances, or even the representative instances But we may select a type, and find out its characteristics. These characteristics must necessarily be possessed by those objects of which it is the type (though in a less marked degree) The process of definition is thus made very simple , for by defining a single type we define all the objects of which it is the type. For example, in defining food, we may select rice as the type We shall find that it possesses the property of nourishment, which property must be possessed by all articles of food in varying degrees The difficulty connected with the marginal instances also vanishes We are to observe whether a particular marginal instance resembles this or that type more—whether, for example, jelly resembles stone or water more, and we shall place it accordingly, and the definition of its type will be its definition

Criticism of Definition by Type —A slight reflexion will show that definition by type is an absurdity For, what is a type? A type is one which possesses all the essential characters of the class in a conspicuous degree Hence, in order to know the type I must have to know the essential marks of the class In other words, the selection of the type pre-supposes the definition of the class, of which it is the type Hence the type does not make definition, but rather definition makes the type

146 Q *What is definition by type? Criticise the theory*
A (See above)

147 Q *'The process of determining a definition is inseparable from classification' Explain this, and discuss the difficulties and limits of definition* (*I A*, 16) *Show the relation of classification to definition* (*B A*, *08*)

Limits of Definition —The following cannot be defined :—(1) Summum genus, as it has no genus higher than itself (2) Elementary qualities, such as milkwhiteness, skyblueness, etc, as they are non connotative (3) Proper names, as they are non connotative (But this is a disputed point See Deductive Logic) (4) Marginal instances, such as sponge, jelly, arsenic, etc., for they possess certain marks of this class, and certain marks of that.

[As for the relation of Classification to Definition see Q 136 As for the difficulties of Definition see Q 145]

148 Q *Explain and illustrate the bearing of definition on generalisation* (*B.A*, 07)

A Definition is generalisation When I am to define *man*, I gather together the individuals called by that name, and find out that they possess in common the essential properties of rationality and animality Thus in defining *man*, I generalise these two attributes over all individual men, and form a general proposition that man is a rational animal But it should be noted that every generalisation is not definition; the generalisation of essential attributes is definition, and the generalisation of inessential attributes is description

149 Q *What do you mean by real and nominal definition?*

A. A definition is said to be real, when it refers to actually existing things, and nominal, when it has no such reference. In other words, "definition is said to be real when it explains the meaning of an actually existing thing: while it is viewed as nominal or verbal, when it merely unfolds the meaning of a name or term, without any reference to the actual existence of the corresponding object. The one may be viewed as clearing up the relation of ideas to things, while the other, of names to notions."

150 Q *Do we define a name, concept, or a thing?*

A. This is a disputed question. Mill holds that all definitions 'are of *names*, and *names* only'. According to Mansel and Ueberweg, definitions are of *concepts* or *notions* While others hold that definitions are of *things*. The controversy can be set at rest by considering the etymological meaning of the term definition. *Definition* etymologically means 'setting boundary to', *i e*, making precise. Now, by definition we surely do not make *things* precise, for things remain just the same after the definition as they are before By definition we only make our *ideas* of them clear. Hence, we define *concepts*, and not things But our concepts cannot be made clear without reference to things, where they have actual things corresponding to them. Hence we conclude that definitions are of *concepts* or *notions*, but that they have reference to things, except those definitions, *e g*, that of centaur, where there are no real things corresponding to our notions It should be observed, however, that in the very process of defining our concepts we define the names, which are the linguistic expressions of the concepts

151 Q. *What is substantial definition?*

A Substantial definition is what we ordinarily mean by definition, *viz*, unfolding the connotation of a term, or what is the same thing, determining the essential characteristics of a class

152 Q *Explain and illustrate:—Genetic definition. (I, A., 21).*

A The definition of a thing is said to be genetic when it describes the process by which we come to form an idea of it. Thus if I define triangle not as a three-sided rectilineal figure (which is the substantial definition), but as a figure formed by a perpendicular plane passing through the appex of a cone, it is a genetic definition, for it describes the way in which the triangle is formed

153 Q. *What do you mean by an inductive and a deductive definition?*

A A deductive definition merely unfolds the connotation of a term, but an inductive definition attempts to ascertain the essential attributes (constituting the connotation) by an examination of particular instances.

⁂ **154 Q.** *Distinguish between definition and description*

A Definition differs from description in that the former states the fundamental and essential properties, while the latter accidental or inessential properties. [For the elaboration of the distinction, see Deductive Logic]

CHAPTER XV.

TERMINOLOGY AND NOMENCLATURE.

155 Q *What do you mean by Terminology and Nomenclature?*

A. These terms have somewhat different meanings. Terminology is a system of names for describing the *qualities, parts,* and *relations* of things, while nomenclature is a system of names to denote the *classes* of things Thus the names *stamens, pistils, petals,* etc., as used in Botany to describe the parts of a flower, belong to the former, while the names *vertebrata, protozoa,* etc., to denote classes of things, belong to the latter.

156. Q *What is the difference between the popular and the scientific use of names?*

A (1) The popular use of a term is often vague, but the scientific use is precise and definite (2) In the popular vocabulary, terms are inadequate, but in sciences there is an adequate system of terms to denote the various parts, qualities, relations, and classes of objects

157 Q *What do you mean by the Transitive Application of words?*

A Words generally pass through successive modifications in their meanings. Words originally used in one sense have come to be used in a wider or a narrower sense Thus they suffer changes in two ways, *viz*—(1) By generalisation, that is, by increasing in denotation (and consequently decreasing in connotation or meaning). For example, the word *letter* originally meant an alphabetic character (A, B, C, etc.), then it came to mean an epistle, next literature, and now in the post office it means any parcel carried by post (2) By specialisation, that is, by decreasing in denotation (and consequently increasing in connotation) For example, the word *story* originally meant an account of an event, whether true or false, but now it means a fictitious account only. This fact of words passing through successive changes in their meanings (whether by addition or by subtraction) is called the *Transitive application of words*

158 Q *What are the requisites of scientific language?*

A I *Every important meaning must have an appropriate name* This means that there should be (*a*) an adequate nomenclature, or system of names for the classes of objects In Chemistry there should be names for all the elements and compounds, in Zoology for different species, genera, etc, and so forth; and (*b*) an adequate terminology This means that there should be (1) names for different parts of objects, *e g*, nerve, muscle, petal, etc., (2) names for different qualities, *e g*, red, sweet, hard, soft, etc, (3) the names for the processes and activities, *e g*, attraction, resistance, motion, etc, and (4) names for the relations of objects, *e g*, kingdom, order, genus, species, etc.

II *Every name must have a fixed and definite meaning.* This will save us from many a confusion and fallacy arising from the vagueness and ambiguity of terms. Hence is the necessity of clearly defining the terms employed by scientists.

159 Q. *What is the Binary Method? What is its use?*

A The binary method is the system of *double naming* used in certain sciences, such as Botany, Zoology, and Chemistry. Thus in Zoology, a double name is used for a species, one for the species itself, and the other to indicate its genus, *e g*, Felis leo (lion), Felis tigris (tiger), and so forth. In Chemistry double names are used for the compounds, *e g*, carbon monoxide (co), carbon dioxide (co_2), etc.

Uses of this method :—(1) It enables us to refer at once to the genus to which a species belongs or the elements of which a compound is formed (2) In Chemistry it not only shows the different constituent elements, but also the proportions in which they are combined (3) It helps our memory by avoiding fresh names for species or compounds (4) It helps us easily to classify the species or compounds

⁂ **160 Q** *Fully explain and illustrate the use of nomenclature and terminology Explain the relation of nomenclature to definition and classification* (*I A*, 12)

A Popular language, though it may be sufficient for the ordinary purposes of life, is not enough to meet the growing demands of sciences In sciences, terms and names are absolutely necessary to denote the various classes, and to describe the minute parts, attributes, and relations of objects, both mental and material Besides, popular language is often vague and ambiguous, and it is necessary to make it precise and definite Hence is the use of terminology and nomenclature.

Naming and Definition —According to those logicians, *e g* Mill, who hold that definition is of names only, definition necessarily presupposes naming Even according to those, *e g* Ueberweg, who hold that we define a concept, definition supposes names, for a concept should perhaps be associated with a name before it is rendered capable of definition But the name supposed by definition is vague and ambiguous, definition gives it clearness and precision. Again, it may be said that *scientific* naming supposes definition, for we must first *definitely* understand an object before we give it a name

Naming and Classification :—Classification supposes naming, for in classifying objects we are to compare their parts and attributes ; but we cannot effectively do so unless they are associated with names Again, naming, in many cases, supposes classification, for we give usually names to classes of objects, and not to individual objects, except in a limited number of cases, *e, g*, names of individual men, countries, rivers, and the like.

CHAPTER XVI

DEMONSTRATION & NECESSARY TRUTHS

⁂ 161 Q *What is meant by necessary truths? Do you think there are any truths which can be known to be necessary? If so, how can they be known to be such? What will be the use of such truths in logical thought?* (*I A.*, 12) *Discuss the validity of the distinction between necessary and contingent truths* (*I. A*, 20)

A Necessary truths have been variously defined or described by different logicians :—(1) Bain defines necessary truth as that which must be true, and contingent truth as that which may or may not be true But this definition of necessary truth is evidently circular, for *must* is equivalent to necessity ; and the definition of contingent truth is self-contradictory, for how may a truth not be true? (2) Spencer defines necessary truth as that the opposite of which is inconceivable, and contingent truth as that the opposite of which is conceivable But Mill and Bain object to this view on the ground that our inconceivability cannot be the measure of necessity, for there are many truths the opposite of which we cannot conceive, but they are not on that account necessary truths For example, many of us cannot conceive that a heavy body can of itself rise up instead of falling down, or that the sun may rise in the west instead of in the east But, for that reason the fall of a body or the rise of the sun in the east is not a necessary truth

Indeed, necessary truths are those which are eternal and immutable, which cannot be changed or made otherwise than they are even by God Himself They are opposed to contingent truths, which depend on the will of God, and are therefore capable of being altered. That the two sides of a triangle are together greater than the third is a necessary truth, because it cannot be altered by any power, finite or infinite. But that the sun rises in the east is a contingent truth, for God may alter it if He chooses The opposite of a necessary truth is self contradictory, but not so the opposite of a contingent truth If we are asked strictly to define necessary truth, we should define it as the truth the opposite of which is inconceivable, not to this or that person, but to the typical person

From the above it follows that axioms and deductions from them are alone necessary truths. And if we regard axioms as intuitive, then necessary truths can be both intuitive and inferential

How necessary truths can be known :—According to Spencer, a necessary truth can be known by the inconceivability of its opposite. According to the intuitionists generally, a necessary truth, if it be an axiom, can be known intuitively, *i e*, by direct consciousness Just as the sun is known by itself, so an axiom is known by itself, because it is self-evident. And if it be a deduction from an axiom, then it can be known by examining the deductive reasoning, *i.e*, by considering whether it strictly follows from an axiom or not According to the empiricists, there can be, strictly speaking, no necessary truths , what are alleged to be necessary truths can, according to them, be known only by an appeal to experience.

From the above consideration it is quite obvious that the question as to whether the distinction between necessary and contingent truth is valid or not is to be answered according to the standpoint we adopt According to intuitionism, there are truths which can be known as necessary, , either intuitively or by a strict process of deduction The distinction is, therefore, quite valid, if we take up this point of view. On the other hand, empiricism bases all truths on experience Now, since experience, however wide its range may be, cannot yield necessity and universality, there are no truths which, according to this view, can be held necessary in the strict sense of the term. Hence it follows that no such distinction can be validly drawn according to the empirical point of view.

The Use of Necessary truths in Logic :—Necessary truths constitute the foundation both of Inductive and Deductive Logic The fundamental laws of thought, *e g*, the Law of indentity and Aristotle's dictum, are the foundation of Deductive Logic. And the uniformity of nature and the law of causation are the grounds of Induction (Elaborate this).

162 Q *What is an axiom ? What is the logical use of axioms ? Give examples of axioms and of their use in reasoning What is the ground of our belief in the truth of axioms ? State different theories on this subject, and give your own opinion with reasons to support it.* (*I. A*, 11).

A An axiom is a self evident necessary truth The characteristics of axioms are that they are—(a) Self evident, *i e.*, they require nothing else to prove them, being themselves the fundamental truths [But the empiricists, *e g*, Mill, deny that, holding that experience is necessary to prove them] , (b) Universal, *i e*, they hold good in all places , (*c*) Eternal, *i e*, they hold good at all times , (d) Necessary, *i e* , they must be as they are, and are incapable of change

Examples —(1) Mathematical axioms, *e.g*, the whole is greater than its part , equals added to, or subtracted from, equals are equal (2) Logical axioms, *e g* , the laws of thought, Aristotle's dictum, the uniformity of nature, the law of causation (3) Axioms of physical sciences, *e g.*, the conservation of mass and motion

[As for the use of axioms see above, and as for the different theories regarding the origin of our belief in them see Q. 28]

163 Q *'Two straight lines cannot enclose a space' State your opinion regarding the logical character of this proposition —as to whether it exemplifies mediate or immediate cognition, and as to the ground or evidence on which it rests* (*I A* , *12*)

A According to Mill, this proposition (which is a Geometrical axiom) is an induction per simple enumeration (as all axioms are)—we observe in many cases that two straight lines, etc , from which we come to the general conclusion Hence it is an instance not of immediate, but of mediate congnition (knowledge) But Whewell objects to this view on this ground among others that it is impossible for us to follow two st lines to infinity so as to be able to observe whether they meet at all or not , we can follow them only to a limited distance Hence the true view seems to be that we know it (as all other axioms) intuitively, *i e*, it is a self-evident truth, and hence is an instance of immediate cognition.

⁂ **164 Q** *What is meant by demonstration ?* (*I A* , *11*) *Explain the nature of demonstrative evidence, and the ground of its claim to a higher certainty than other kinds of evidence.* (*B A* , 00)

A The term *demonstration* means showing or pointing out a thing so clearly that there remains no manner of doubt as to its truth There are two ways in which things may be demonstrated :—(1) Demonstration may be immediate. "A thing capable of being perceived is demonstrated when it is actually perceived. The fact that two volumes of hydrogen and one volume of oxygen make water is demonstrated when we actually see it done in a chemical laboratory. (2) But in Logic, the term demonstration is used with respect to mediate or inferential truths. To demostrate means in Logic *to deduce a conclusion which is absolutely certain* But a conclusion can be absolutely certain if the premisses as well as the process of reasoning are absolutely certain. This is the case only if the premisses are axioms or necessary truths, and the process of reasoning is deductive (syllogistic or mathematical) Hence the conclusions of Geometry can be said to be demonstrative truths

From the above it is quite clear that other kinds of evidence are less certain than demonstrative evidence In induction, and esp. in analogy, the process of reasoning (from some to all or to some) is far less certain than deduction Again in ordinary syllogistic reasonings, the premisses are more or less uncertain, as being supplied by previous inductions

165 Q *Mathematics and its applications are called exact sciences, and their conclusions are characterised as systems of necessary truths Show what is implied in those designations, and whether they are justifiable or not* (*I A.*, 09).

A An exact science is that in which the premisses are clear, unambiguous, and certain, and the process of reasoning is the rigorous form of deduction Now, these two conditions are fulfilled in Mathematics and its subordinate sciences, as is clear from the following considerations :—(a) The definitions and axioms of Mathematics, which supply its premisses, are clear and unambiguous No one is liable to mistake a line for an angle, a triangle for a square, a parabola for a hyperbola, and so forth (b) They are also necessary in the sense that, as Welton observes, we can think them only in one way, because the conditions implied by them are constituted by our own nature (c) The process of inference is strict deduction, consisting in deducing conclusions from axioms and definitions.

From the above considerations it is quite evident that the conclusions of Mathematics are necessary truths But Mill does not regard them as necessary, on the ground that Euclid's definitions, such as that of *point* or *line*, are only hypothetical, having no foundation in reality The conclusions deduced from such definitions must necessarily be only hypothetically true. The only certainty that we have in Mathematics is the *certainty of inference*—granted the premisses, the conclusions necessarily follow from them , but that certainty pertains to all deductive sciences.

CHAPTER XVII

THE NATURE, FUNCTION, AND VALUE OF THE SYLLOGISM

⁂ **166 Q** *What are the charges brought against the syllogism by Mill? How will you meet them?*

A. Two charges have been brought against the syllogism by Mill, viz.—

(1) The syllogism is not the usual mode of reasoning. Men usually reason from particulars to the particular, and not from particulars to the general and then from the general down to the particular again.

Reply to this Charge:—It is true that men do not usually reason syllogistically (*i. e*, from the general down to the particular) But that does not at all affect Logic, for Logic does not consider how men *do* reason Psychology is concerned with that Logic indicates the way as to how men *ought to reason* and must reason if they are to reason correctly. Hence it is clear that Mill confounds the function of Logic with that of Psychology when he brings the above charge

(2) The syllogism, as a mode of proof, involves the fallacy of the *petitio principii*. The fallacy of the *petitio principii* is committed, when the conclusion is unfairly assumed in the premiss Now, in a syllogism, *e g*., 'All men are mortal, Ram is a man, therefore Ram is mortal,' the conclusion 'Ram is mortal' is assumed in the major premiss "All men are mortal'; for if it be not contained in the major premiss, then it cannot be proved by the major premiss, the rule of the syllogism being that the conclusion must not contain more than the premisses

Reply to this Charge:—(a) The above charge, as Whately points out, is founded on a misunderstanding The conclusion is not surely *explicitly* contained in the universal major, but is *implicitly* contained When I laid down the universal proposition, say, 'All ruminants are herbivorous' I did not know then that 'all ruminants' included camels

Therefore, when the conclusion 'All camels are herbivorous' is deduced, it is a new fact to me, though it was implicitly contained in the universal premiss The universal premiss is, indeed, too vague to bring home to me all the particulars which it implicitly contains

Having understood the distinction between *explicit* and *implicit* we can see that the syllogism does not involve the fallacy of the *petitio principii* The *petitio principii* is relative to the degree of knowledge What is a *petitio principii* to a teacher is not so to a pupil. To God, who knows everything immediately, every form of reasoning, deductive as well as inductive, involves a *petitio principii*, but not so to man Now, when the universal proposition is stated, I do not know that it contains the conclusion, though it is true that it does contain it implicitly Therefore, to me the syllogism does not involve a *petitio principii* No one can doubt that the definitions and axioms of Geometry implicitly contain all the geometrical conclusions But on that account it cannot be said that when the definitions and axioms are stated, we know at once all the conclusions Mill was, indeed, wrong to ignore the essential distinction between *explicit* and *implicit*

(b) Another misunderstanding on which the above charge is founded is that it is supposed that the conclusion is deduced from the major premise alone, making the minor premise redundant. But, as a matter of fact, the conclusion is drawn neither from the major nor from the minor premise alone, but from both conjointly.

167 Q *Examine the ground for the rejection of syllogistic reasoning as petitio principii.* (*B A*, 99) *The charge against the syllogism that it involves a petitio principii is founded on a misunderstanding Explain the nature and supposed warrant (ground) for the charge, and the misunderstanding on which it is founded* (*I A*, 09). *On what ground has it been argued that the syllogism involves a petitio principii? Do you consider the argument to be sound? Give reason* (*I. A*, 12)

A [See above.]

168 Q *'All inference is from particulars to particulars' Test this statement* (*B A H*, 05)

A This view, based upon nominalism, is held by Mill, according to whom all of us reason from particulars to particulars, and consequently the syllogism is not the usual mode of reasoning But this view is not altogether correct, for, as Mill himself admits, we at times also reason from the general to the particular And even if this view is quite correct, Logic is not affected by it, for it is not concerned with what inference is, but with what it ought to be.

169 Q *Discuss the nature of the syllogism* (*B A H*, 06). *Give a statement of the true logical value of the syllogism.* (*B. A*, 05) *Explain the nature and function of syllogistic reasoning* (*B A*, 08, *H.* 07.)

A. The Nature of the Syllogism —The formal logicians generally regard the syllogism as a mode of *proof*, the conclusion being deduced *from* the premises By some of them it is even regarded as the only mode of reasoning But this view of the syllogism is objected to by Mill, acc to whom we reason from particulars to particulars When I conclude that Ram is mortal, I do not draw this conclusion from the universal major premise 'All men are mortal', but from those particular premises, *e. g*, A has died, B has died, and so forth, by means of which the universal premise itself was established, so that the evidence of this particular conclusion is the same as the evidence of the universal major premise This fact is expressed by saying that the conclusion of a syllogism is not drawn *from* the major premise, but *according to* it, that is, according to the direction indicated by it, *viz*, on the ground of those particular premises which have established it From this it follows that the syllogism does not *prove* the conclusion, but only *interprets* the major premise. Just as a judge interprets the law framed by the legislator, and applies it to a new case, exactly so the syllogism interprets the universal major premise, and applies it to a particular case. When from certain particular cases of mortality I lay down the induction that all men are mortal, the *inferential* process is finished there It remains next to interpret this universal proposition established by induction, that is, to consider whether the particular case of Ram fulfils the requisite conditions, so as to enable us to bring Ram under the class *men* and say that he is mortal, and this is syllogism The universal major premise is a short record or register of the inference already made on the ground of the particular premises, the minor premise brings a new case under the universal proposition, and the reasoning consists in applying the major premise to this new case.

The Function and Value of the Syllogism:—According to some logicians, *e g.*, Whately, the syllogism is the universal type of reasoning, and it not only secures the correctness of the conclusion, but also proves it. On the other hand, a different class of logicians holds that the syllogism is altogether useless, as involving the fallacy of the *petitio principii* Mill regards both these views as extreme, and holds that though the syllogism involves a vicious circle, yet it is not useless, for—(*a*) The syllogistic form, *i e*, the form of passing through the general proposition in our reasoning, is a most important security for the correctness of the process of generalisation For, when we reason from particulars to another particular we are apt to be negligent in view of the trifling nature of the task. But when we are first to establish a general proposition, we are apt to be very careful in consideration of the importance of the task We are then expected to examine as many instances as possible, and to be free from bias in drawing the inference (*b*) The syllogistic rules are a security for the correct interpretation of the general proposition Reasoning is, indeed, from particulars to the particular, but in a complicated case we are likely to commit a fallacy. But if in such a case we throw the argument into the syllogistic form we are sure to arrive at a true conclusion, because we have the unerring guide of the syllogistic rules

170 Q *'Induction is the process of establishing general propositions, and deduction (syllogism) is the interpreting of them. Explain and illustrate this Is the theory of reasoning here implied admitted by logicians? If not, what other theory has been held?* (*I A*, *10*), *The problem of logic may be summed up in two questions —"How to ascertain the laws of nature, and how to follow them into their results" Explain this fully, showing the kinds of reasoning involved in these two questions, with illustrations* (*I. A*, *10*)

A [See Q. 169 The above theory of deduction is held by Mill, but is not admitted by formal logicians, *e g.* Whately, to whom the syllogism is a mode of proof]

CHAPTER XVIII

RELATION OF INDUCTION AND DEDUCTION.

⁂ 171 Q *Explain what you consider to be the true relation of Induction and Deduction, illustrating your meaning by examples, and discuss the claim of Induction to be a separate department of Logic.* (*I A*, 09). *Distinguish carefully between deductive and inductive reasoning, and discuss fully the question whether induction precedes deduction or deduction precedes induction.* (*I, A*, 20)

A In determining the relation between induction and deduction it is necessary to consider which one of them is prior to the other We know that in a syllogism, at least one premise must be universal, and the universal proposition (unless it is a necessary truth) can be had only by an induction. Hence it seems that induction is prior to, and the basis of deduction But a deeper insight shows that all inductions are at bottom deductive in their nature Every induction can be thrown into the syllogistic form, with a particular uniformity of nature as the major premiss For example, the induction 'All men are mortal' may be thrown into the following syllogistic form ,—

Whatever is true of Ram, Jadu, Hari, Kali, and some others, is true in all *similar* cases *i, e*, in cases of all men. (Major).

Mortality is true of Ram, Jadu, Kali, Hari, and some others (Minor)

∴ Mortality is true in all similar cases, *i e*, in cases of all men. (Conclusion)

That is, All men are mortal

Hence we conclude that, *proximately* speaking, induction is the basis of deduction ; but, *ultimately* speaking, deduction is the basis of induction

The difference between induction and deduction has been variously expressed by different logicians (1) According to Jevons, induction is the inverse process of deduction The meaning of this is not very clear. Perhaps he means that when a hypothesis is verified by *deducing* conclusions from it, it becomes an induction. Venn objects to this view, saying that such deduction is not induction. Induction consists in the final generalising process (2) Bacon describes induction and deduction as ascending and descending processes. But this is only a figurative way of describing the relation (3) According to Fowler, in induction we proceed from effects to causes, and in deduction, from causes to effects. But in induction, too, we often proceed from causes (real or supposed) to effects. (4) Buckle says that in induction we proceed from facts to ideas, and in deduction from ideas to facts. But we often reason from facts to facts or from ideas to ideas. (5) Some say induction is analysis, and deduction is synthesis But we may as well hold the opposite view

According to the formal logicians, *e g*, Mansel, induction is not a separate department of Logic All inductions are ultimately deductive in their nature, and can be expressed as syllogisms, with a uniformity of nature as the major premiss Hence, viewed ultimately, induction cannot claim to be a separate department of Logic But viewed proximately, there is a clear distinction between induction and deduction, the former treating of material, and the latter of formal truth. Hence, from the proximate point of view, induction can be regarded as a separate department of Logic.

172 Q *Explain clearly the difference between deductive and inductive inference* (*I A*, *14*) *Explain and illustrate the relation and the distinction between induction and deduction.* (*B A*., *97*)

A. - (See above).

173 Q *Is it possible to reduce induction to deduction, and vice versa?* (*B A*, *07*) *Can induction be reduced to syllogistic reasoning? Fully discuss this question, examining the different attempts that have been made to resolve the former into the latter* (*I A*, *18*)

A Three different attempts have been made to reduce induction to the syllogistic form :—

(1) Aristotle's attempt —

A, B, C, D, and others are mortal
A, B, C, D, and others are all men
∴ All men are mortal,

[Here *mortal* is proved of *all men* Aristotle gives peculiar meanings to the terms *major*, *middle*, and *minor* The term which is most general is called by him *major*, the next general term is called the *middle*, and the least general, *minor* Hence in the above syllogism (if it is a syllogism at all), *mortal*, *all men*, and A, B, C, D, etc, are respectively the major, the middle, and the minor Now because *mortal* is proved of *all men* by means of *A*, *B*, *C*, *D*, etc, Aristotle describes his syllogism as proving the major term of the middle by means of the minor]

This syllogism, if it can be regarded as a syllogism at all, is palpably absurd When, for example, I say that A, B, C, D, and others are mortal, does the word 'others' include the rest of men besides A, B, C, and D? If so, then the conclusion is identical with the major premiss, and so is not syllogistically drawn If not, then the conclusion does not follow from the premisses

(2) Whately's and Aldrich's attempt —

The men whom I have observed and the men whom I have not observed are mortal

But all men are the men whom I have observed and the men whom I have not observed

∴ All men are mortal

This attempt is alike futile How do I know that the men whom I have not observed are mortal? I can only know this by an inductive leap This shows that the syllogism, which claims to prove an induction, itself involves an induction, thus indicating the truth of the inductive process.

(3) [See Q 171, *viz*, whatever is true of Ram, etc, which seems to be the true syllogism]

The above are the attempts to reduce induction to deduction Mill, on the other hand, attempts to do away with deduction as a form of reasoning by holding that all reasoning is from particulars to particulars, with an option, indeed, of passing through a general proposition Mill says that as a mode of proving the conclusion, the syllogism involves the fallacy of the *petitio principii* But we know that Mill's charge against the syllogism is founded on a misunderstanding, and that therefore his denial of the syllogism as a mode of proof is unfounded.

174 Q *What is meant by a deducative and what is meant by an inductive science? State the principal deductive and inductive sciences, explaining in each case your reason for considering it either inductive or deductive A science at one time inductive may become at another time more or less deductive, explain this.* (*I. A.*, 13)

A. An inductive science is that in which we establish laws by the observation of, and experiment upon, particular facts, and a deductive science is that which consists in deducing conclusions from established principles or laws From this it is evident that many sciences are at the beginning inductive But in course of the progress of a science, as more and more laws get established, it becomes more and more concerned with deducing conclusions from them, and thus becomes more and more deductive

Inductive and Deductive Sciences :—(1) Metaphysics. It is deductive acc to the rationalists, because they reason down from their fundamental assumptions, and inductive acc. to the empiricists, because they rise from the facts of experience to the ulimate principles The truth is that it is both inductive and deductive, because the deductions from the fundamental assumptions must be verified by experience (2) Logic. It is both inductive and deductive (Give reasons) (3) Psychology It is mainly inductive, because a psychologist has to discover laws by observing and experimenting upon psychological facts. (4) Ethics. It is mainly deductive, because the rightness of actions is to be deduced from certain principles (5) Sociology It is both inductive and deductive, because it is based upon observed facts as upon some psychological principles. (6) Mathematics. It is deductive, because a mathematician has only to deduce conclusions from definitions and axioms (7) Physics and Chemistry They are mainly inductive, as they are much more concerned with establishing laws than with following laws into their results (8) Physiology, Anatomy, and Geology They are inductive, as only a few laws have as yet got established in them (9) Biology It is mainly inductive, and partly deductive (10) Astronomy, Politics, Medicine. They are both inductive and deductive, because we have to rise up from facts of experience to principles, as well as, come down from principles to facts

CHAPTER XIX

INDUCTIVE FALLACIES

175 Q, *What are the fallacies incident to induction?* (*B*, *A* *00*) *State and explain the principal fallacies incidental to inductive inferences* (*I. A*, 13)

A The inductive fallacies are either non inferential or inferential —

I **Non-inferential Inductive Fallacies** —

A ~~The Fallacy of Non~~-observation, which is committed when we fail to observe a circumstance which we ought to observe.—It is of two kinds :—

(a) Non observation of *an entire instance* Many of our superstitions are due to this The belief that dreams are actually fulfilled in life is due to the non-observation of negative instances, *i e*, instances in which they have not been fulfilled Beliefs in fortune-telling and other kinds of prophecy are mainly due to overlooking negative instances

(b) Non observation of a *part of an instance*, *i e*, of an accompanying circumstance Suppose a student's failure in an examination is due to his father's death as much as to his habitual neglect of studies But he may naturally overlook the latter factor and solely ascribe his failure to his father's death

B. The Fallacy of Mal observation, which is committed when we observe something wrongly, or seem to observe what we really do not observe, as when I mistake a piece of rope for a snake, or when at dead of night I mistake a small plant for a ghost, or when I seem to observe that the sun is moving, the fact being that the earth is moving. All illusions are due to mal observation.

C The Fallacies of Definition Most of them arise from the violation of the formal rules of definition (for which see Deductive Logic) Here only it may be mentioned that it is a fallacy to regard a formal definition to be a real one, as when we believe that the formal definition of man as a rational

-animal is realy true, for most men are in fact more often irrational than rational It is also a fallacy to attempt to define a term which cannot be defined, as when I attempt to define consciousness, which is an elementary fact.

D The Fallacies of Classification [The Fallacies of Division are evidently also the fallacies of classification, for they are really the very same process viewed from opposite standpoints For the fallacies of Division, see Deductive Logic]. In classification errors often arise from mistaking superficial resemblance for essential one,-as when we classify bats under birds on the ground that bats can fly It is also a fallacy to attempt to classify objects which cannot be classified, e g, the summum genus

II Inferential Inductive Fallacies :—

(A) False Generalisations :—

(a) Generalisation for which we have no evidence whatsoever, as for example, inferences as to what may go on in the remotest part of the universe.

(b) All universal negative propositions other than mathematical and causal It is a fallacy to say 'No crow can be white,' 'No scarlet flower can be fragrant,' 'No Englishmen can be unpatriotic', and so forth But universal negative propositions are allowable when based on the law of causation, e g, 'In no cases can cholera be caused by drinking pure water' Again, in Mathematics, such generalisations are valid, e.g, 'In no cases can two and two make ten', 'In no cases are the three angles of a triangle less than two right angles,' and so on

(c) Generalisations from the past negative instances of the form 'what has not happened never will,' as when we say, 'Women have not hitherto been equal to men, therefore they will never be equal to men'

(d) To extend an empirical law beyond the narrow limits of time and place, as when we say that everywhere blue-eyed tom-cats are deaf.

(e) To regard an empirical law to be as certain as a law of causation

(B) The Fallacies of Causation, which are as follows :—

(a) It is a fallacy to assign a supernatural or a metaphysical cause, instead of a natural cause, as when we ascribe the death of a man to the anger of a goddess or to the will of God.

(b) It is a fallacy to mistake bare co existence for causation, as when we regard either of day and night to be the cause of the other, or when we regard the scarlet colour of a flower to be the cause of its non fragrance

(c) It is a fallacy to mistake causation for bare co existence, *i e*, not to admit causal connexion where it does exist, as when we refuse to admit causal connexion between air and sound, even when it is proved by the M of Difference.

(d) Post hoc ergo proper hoc (after this, therefore, *on account of* this). This is a very common fallacy, corresponding to the Nayayika fallacy *kakataliya* (काकतालीय). When a student goes to the examination hall *after* seeing the face of a particular man, and gets plucked, he is prone to believe that he has failed *on account of* seeing his face If a member of a family dies after the birth of a child, the child is considered to be the cause of his death A comet appearing before the fall of an empire is often regarded as the cause of its fall

(e) It is a fallacy to mistake a condition for a cause, as when Napoleon's Russian Expedition is regarded as the cause of his downfall, whereas it is one of the conditions, the other conditions being the shortage of man-power in France, internal disorder in France, etc

(f) It is a fallacy to mistake a single consequent for the whole effect, as when I believe that the whole effect of the stimulant I am using is the refreshing of the system, forgetting that it also produces disorder in the liver.

(g) It is a fallacy to neglect the negative conditions in defining a cause.

(h) It is a fallacy to neglect the plurality of causes The neglect of studies is a cause of failure in the examination; but it should not be thought that whenever a boy fails in an examination, he has neglected his studies, for there may be other causes of failure.

[The fallacies referred to in (b), (d), (e), consist in taking something to be a cause which is really not a cause Such fallacies may generally be designated fallacies of *Non causa pro causa*].

C The Fallacies of Explanation [See Q 115].

D The Fallacies of Analogy, which arise from regarding unimportant or superficial resemblance for essential or deep seated one.

[Vide Q 94 for examples of bad analogy] Sometimes, a figurative way of describing similarity may be mistaken for real similarity, as when we reason thus —The capital of a country is like the heart of an animal Therefore, the increased size of the capital is a disease.

176 Q *Explain and illustrate the fallacies of non observation and mal observation* (*B A*, 02) *Instance the common forms of erroneous generalisation* (*B A*, 03)

A [See above)

177 Q *State and explain some of the more important of non logical fallacies* :—

A (A) The *petitio principii*, as when the conclusion is unfairly assumed in a premiss, of which the syllogism is a common example [See my Deductive Logic made Easy, Q 200.]

(B) The falsity or undue assumption of premisses Sometimes we prove a conclusion by premisses which are false, or for which we have no evidence whatsoever, or at least, no sufficient evidence, as when a foreigner says, 'Ram must be a liar, as he is an Indian,' thereby implying that all Indians are liars, for which there is no sufficient evidence

(C) The *Ignoratio Elenchi*, *i e*, arguing beside the point, the conclusion having no connexion with the premisses It has various forms, of which the most important are :—

(a) *Argumentum ad populum*, *i. e.*, trying to prove or refute something by appealing to the passions and prejudices of the people, instead of arguing to the point, as when a man attempts to refute Darwin's theory of Evolution by thus addressing himself to the people, "Will you accept Darwinism ? Will you believe that your fathers and mothers are descendants of monkeys ?"

(b) *Argumentum ad verecundium*, *i. e*, trying to prove something by unfairly appealing to authority, instead of arguing to the point. In the above example, a follower of Darwin may address himself to one thus—'Will you not accept the evolution theory, seeing that it has been advocated by no less an authority than Darwin himself, etc ?' It should be noted that reverence for authority is not a fallacy, but undue reverence.

(c) *Argumentum ad hominem.* This fallacy is committed when the argument has bearing not upon the real point, but upon the conduct, character, or avowed opinion of one whom I am to refute Suppose, John holds a particular religious doctrine which I want to refute, and I proceed thus —"This doctrine cannot be true, for it is held by John who is a well-known turn coat' Here I commit the fallacy of argumentum ad hominem, for I argue not to the point, but to the man

(d) *Argumentum ad Ignorantiam,* which is an argument to the ignorance of the opponent This fallacy is committed when I unfairly throw the burden of proof upon an ignorant opponent Suppose, I uphold the atomic theory, and am asked to prove it Having proceeded some way, and finding difficulties, I turn round, and ask my opponent to prove that atoms do not exist. But this is unfair, for it is my business to prove it, I am not justified in taking advantage of the ignorance of my opponent, and ask him to prove a negative proposition which it is often extremely difficult, and sometimes impossible, to prove

D. *Hysteron proteron* This fallacy is committed when the right order of things is inverted, as when we attempt to deduce a premise from a conclusion, or a cause from an effect. This fallacy is illustrated in the theory of Emotion held by Prof. James We believe that we laugh, because we are happy ; we strike a man, because we are angry, we run away, because we are afraid, we cry, because we are afflicted with grief, and so forth But James says that this is a wrong theory According to him, we are happy, because we laugh, we are angry, because we strike a man, we are afraid, because we run away, we are afflicted with grief, because we cry, and so forth

178 Q *Test the following arguments* —

[In testing an inductive argument the student will do well to bear in mind the following instructions .—(a) It is not enough simply to say that the argument is correct, or that it commits such and such a fallacy The student will always assign reasons why he considers it so Bare statement unsupported by reasons will carry no marks (b) The student will mention only inductive or non-logical fallacies in the inductive paper, unless he is expressly asked to mention any fallacy, deductive or inductive, as was asked in 1909 (c) When an argument commits more than one fallacy the student will confine his attention to the most obvious and the most important one If he has time he will briefly refer to the other fallacies it may commit (d) The student will mention the technical name of the fallacy, wherever that is possible. Where it is not possible, he will describe the fallacy. (e) A narrower answer is always preferable to a wider one. When, for example, an argument commits the fallacy of *argumentum ad hominem*, it is unsatisfactory to say that it commits the fallacy of *ignoratio elenchi* The more specific the answer, the better. (f) A logical fallacy is generally to be preferred to a non logical one]

(1). *The sun will rise to-morrow morning* (I A , 09)

A The validity of this proposition depends upon the validity of the universal proposition that the sun rises everyday. Now this universal proposition is an induction per simple enumeration based upon a wide range of experience, and as such is only highly probable, and not absolutely certain. The given proposition is, therefore, only highly probable And if we regard it as such, there is no fallacy But if we regard it as absolutely certain, we shall be committing the fallacy of regarding an empirical law to be as certain as a law of causation

(2) *The lower animals feel pain just as we do.* (*Do*).

A This is an argument from analogy. If the term pain means only *physical* pain, then the argument is all right , for the resemblance is important for the purpose, *viz* , that both possess a nervous system which is susceptible to pain But if pain means *mental* pain as well, then the argument is false, for the mental constitution of a lower animal essentially differs from ours.

(3). *He will die within a few hours , he has been bitten by a cobra* (*Do*)

A. The assumption is that all cobra-bitten persons die within a few hours of being bitten But there is no justification for such an assumption, for cobra-bitten men have been known to survive, or at any rate survive for some days. Hence the fallacy of the undue assumption of premiss.

(4) *The factory Commissioners say in their report :— The past and present conditions of work in factories are undoubtedly calculated to cause physical deterioration , and*

we are struck with the marked absence of elderly men among the operatives (*Do*).

A The argument evidently is that the marked absence of elderly men is due to physical deterioration. But the cause of their absence may be something else, such as discontent owing to the lower standard of wages Hence the fallacy arises from ignoring the plurality of causes.

(5) *Intermittent fever is found only in places where there are marshes, even though they differ in every other respect* (*Do*)

A The desired conclusion is that marshes are the cause of intermittent fever The argument is evidently based on the M of Agreement, for the different instances of intermittent fever agree only in another respect, *viz*, marshes. But we know that the M of Agreement cannot establish causal connexion with any degree of certainty Hence we can regard the conclusion as but highly probable, and not certain

(6) *The inner world attains the light of knowledge through seven organs of sense, therefore, some mediæval astronomers said there must be seven planetary bodies to illuminate the outer world of nature* (*Do*)

A The argument is evidently of the analogical type The reasoning is that the outer world of nature agrees with the inner world of mind in respect of *light*, therefore it must agree also in respect of the number of the sources of light Here the term *light* is used with regard to mind in the sense of knowledge. But knowledge is said to be light figuratively. Hence the resemblance is only figurative, and from a figurative resemblance no such conclusion can be drawn Hence it is an instance of bad analogy

(7) *Napoleon's Russian expedition was the cause of his downfall.* (*I. A*, 10.)

A The fallacy of mistaking a condition for the cause There were surely other conditions of his downfall, such as the internal disorder of France, fall in the man-power of France, etc

(8) *A house without tenants, a city without inhabitants, present to our mind the same idea as a planet without life, a universe without inhabitants The conclusion here evidently is that planets and stars are inhabited* (*I. A.*, *11*).

A. This is evidently an argument from analogy But a city or a house resembles a planet or a star only in that both are places. We are not aware of any points of resemblance important for the purpose. It may be that there is no atmosphere in many of the stars or planets, or that the temperature there is too hot or too cold The argument is, therefore, an instance of bad analogy.

(9), *Galileo saw with his telescope that the planet Jupiter is a centre about which several satellites revolve, receiving light and warmth from him, and appealed to this fact as an argument that the sun is a centre about which the earth and other planets revolve as satellites* (*I. A*, 12)

A Here the sun resembles Jupiter in respect of giving light and warmth, whence it is inferred analogically that because Jupiter has several satellites, the sun must have some But the resembling points are not important for the purpose (say why), and hence the argument is not a case of good analogy.

(10) *The terror ceased immediately after the death of Robespierre, therefore, Robespierre was the cause of the terror* (*I. A.*, 13

A Evidently the M of Difference is sought to be applied here. It may be put thus ;—When R was, the terror was, and when R was not, the terror was not. But we know that the condition of the M of Difference is very strict *viz*, that the two instances must agree in all other respects save in respect of two phenomena As we cannot expect the fulfilment of such a strict condition in so complicated a case, the M of Difference does not apply here. Hence the fallacy is that of *post hoc ergo propter hoc*

(11). *The people of England are wealthy, because they are industrious.* (*I A*, 14)

A The assumption here is that all industrious people are wealthy. But this is a false assumption, for a great many industrious men are known to be poor, Hence the fallacy is that of undue assumption of premiss

(12) *If justice consists in keeping property, the just man must be a kind of thief, for the same kind of skill which enables a man to defend property will also enable him to steal it* (*Do*)

A. The kind of skill may be the same in both the cases , but the difference is that the honest man does not misapply the skill as the thief does. Hence the conclusion that the honest man is a kind of thief is wide of the mark

(13) *As I sat down to study this morning, the man in the adjoining room began to play on the harmonium He must therefore be a very malicious person* (*Do*)

A. Here there is a coincidence of two phenomena, *viz.*, my study and the man's playing on the harmonium. The question is whether this coincidence is accidental or causal. Here we have a single instance of coincidence, and not a sufficient number so as to be able to eliminate chance. Hence no causal connexion can be presumed here The fallacy, therefore, is that of mistaking an accidental coincidence for causal connexion

(14). *This patent medicine must be very efficacious, for all the testimonials speak of the marvellous cures effected by it* (*Do*).

A. This is a case where personal observation is quite possible But instead of relying on my own experience I unduly rely on authority Hence the fallacy is that of *argumentum ad verecundium*

(15). *We ought not to go to war, for it is wrong to shed blood* (*Do*).

A The reason adduced against war is that shedding blood is wrong. But this is false, for shedding blood for a righteous cause in not necessarily wrong Hence the fallacy is that of falsity of premiss

(16) *Since it is just to take interest it is right to exact it from one's father* (*I A., 15*)

A This is a fallacy of accident, consisting in arguing from a general case to a special one, for taking interest may be just *generally*, but not taking it forcibly (*exact* means taking forcibly) from one's father

(17). *Opium causes sleep, because it has a soporific virtue.* (*Do*).

A This is an instance of false explanation, consisting in varying the expression , for causing sleep is equivalent to 'having a soporific virtue,' though disguised in different words.

(18) *A nation must ultimately perish, because it is an organism, and organisms grow old and die.* (*Do*)

A. The argument is based on a comparatively superficial resemblance between a nation and an organism. They resemble each other in so far that in each case the parts are vitally related to the whole. But the point of difference is essential, *viz*, that in the case of an organism the parts are not conscious and free as in the case of a nation Hence it is an instance of false analogy.

(19). *We see the sun rise and set every day, therefore the sun does actually rise and set* (*Do*).

A. The sun does not really rise and set, we wrongly observe it to rise and set Hence it is an instance of malobservation.

(20). *Unhealthiness in the parent is not the cause of unhealthiness in the children, because many unhealthy persons have perfectly healthy children.* (*Do*)

A. The argument is all right. For unhealthiness in the parent cannot be the cause, because in many cases it may be present without being followed by unhealthiness in the children. It cannot even be held as a condition or part of the cause, for in that case it would have prevented the effect to a certain extent But it does not do so, for it is stated that perfectly healthy children are born of unhealthy parents.

(21). *So far as my experience goes, A has been invariably preceded by B. I, therefore, conclude that B is the cause of A.* (*I A., 16*).

A. The conclusion is evidently an induction per simple enumeration. We know that such an induction must examine a very large number of instances in order to give a somewhat satisfactory result. But however large may be the number of instances observed, it cannot pretend to establish a causal relation. In the present case the range of observation is very limited, for I rely simply upon my own experience. Hence we are by no means justified in inferring a causal connexion between A and B

(22) *Women as a class have not hitherto been equal to men, therefore they are necessarily inferior to men* (*Do*)

A. This is instance of false generalisation, as being based on past negative instances It may be that women have not hitherto been able to come up to men owing to some tricks on the part of the latter, and that when those mean tricks will be discovered by them, they will be able successfully to resort to every means to be equal to men.

(23). *The metropolis of a country is like the heart of an animal. Therefore, the increased size of the metropolis is a disease* (*Do*).

A This is an instance of analogy understood in the sense of the resemblance of ratios As usual, the resemblance here is a figurative one Conclusions based on such figurative resemblances are often unreliable Hence it is an instance of bad analogy.

(24). *A habitual drunkard who studied hard for the army in his youth has got shattered nerves, therefore the cause of his shattered nerves is his hard study in youth.* (*Do*).

A This is a form of non causa pro causa, arising probably from non observation, for a remote antecedent is taken to be the cause, overlooking a constant proximate circumstance, *viz*, the habit of drinking.

(25) *The great famine.. agrarian crime* (*Do*).

A The conclusion is evidently founded on the M. of C. Variations, for the agrarian crime has been found to increase or decrease in proportion to the increase or decrease of famine But the range of observation is here so much limited (being confined within a single island and between the years 1845 and 1851) that no conclusion can be based on it with any degree of certainty Hence all we can say is that the concomitance of the two phenomena *suggests* a causal connexion, and not that it *proves* the causal connexion beyond question

(26) *The mind must be a function of the brain, since any serious injury to the brain is always followed by the loss of consciousness* (*I A*, 17)

A. Experience tells us that mental disorder is also followed by brain disorder as much as the latter is followed by the former. Hence the true conclusion is that either there is a relation of mutual causation subsisting between them, or both of them are the co effects of some common cause. We are not, therefore, justified in concluding that the mind is the function of the brain.

(27) *The flood was evidently due to the wrath of the goddess, since it began immediately after she had been slighted, and it subsided after propitiatory sacrifices.* (*Do*).

A Evidently the M. of Difference is sought to be applied here The argument may be briefly put thus :—"When the anger of the goddess was present, the flood was present, and when the anger disappeared, flood disappeared too; therefore, her anger is the cause of the flood." But as we cannot be sure in so complicated a case that the other circumstances have remained the same throughout the M. of Difference does not apply here. Hence the fallacy of *post hoc ergo propter hoc.*

(28) *Steel, when brought to white heat in the fire must be plunged into cold water in order to obtain the requisite temperature. Similarly, human body, after the steam bath, on being cooled down, becomes strong and hardy.* (*Do*)

A. The resemblance between steel and human body is superficial, and the difference is essential, for human body is endowed with a sensitive nervous system, which cannot bear the rude shock of sudden change in temperature Hence it is an instance of false analogy.

(29) *The human soul must be diffused over the whole body, because it animates every part.* (*Do*)

A The argument rests on a materialistic conception of the soul. Just as a material body cannot act somewhere without being actually present there, so it is thought that the soul cannot act somewhere without being actually present there, forgetting that the category of space is not applicable to the soul, *i e*, the soul does not exist in space. Hence it is an instance of false analogy.

(30) *Education is clearly the source of all discontent, since the educated, not getting suitable employment, are dissatisfied with their condition in life.* (*Do*).

A The conclusion is that education is the source of *all* discontent, *i e*, education is the *only* cause of discontent. Because discontent is the effect of education it does not follow that there can be no other cause of discontent except education. Hence the argument is fallacious, as ignoring the plurality of causes

(31) *What would...degenerate times.* (*Do*).

A. The fallacy of *argumentum ad verecundium* coupled with that of *argumentum ad populum*; for an attempt is made to prove the badness of the measure not by arguing to the point, but by appealing to undue reverence for the authority of the ancestors, as well as by trying to rouse the passions and prejudices of the audience.

(32). *Punishment must have some other and higher justification than the prevention of crime, for if punishment were only for the sake of examples it would be indifferent whether we punished the innocent and the guilty, since the punishment, considered as an example, is equally efficacious in either case* (*I. A.*, 18)

A. The argument commits the fallacy of the falsity of premiss, for it is said that it would be indifferent whether we punished the innocent and the guilty But this is by no means true, for if we punish the innocent and the guilty alike, then we shall be dissolving the distinction between them, and as a consequence everybody, including the innocent, will naturally be inclined to crimes

The latter part of argument involves the fallacy of the *petitio principii*, for the statement 'the punishment considered .. ...either case' means just the same as the statement 'if punishment......the guilty,' though disguised in different words

(33). *Women as a class have not been hitherto equal in intellect to men, therefore they are necessarily inferior* (*Do*)

A. (See No 22)

(34). *Moisture bedews a cold metal or stone when we breath on it The same appears on a glass of ice-water and in the inside of windows when sudden rain or hail chills the external air Therefore, when an object contracts dew it is colder than the surrounding air* (*Do*)

A. The argument is evidently founded on the M of Agreement, for the different instances of dew are found to agree only in one other circumstance, *viz*, the object being colder than the surrounding air. Since the argument rests simply on the M of Agreement, we cannot infer a causal connexion between these two phenomena with any degree of certainty The given conclusion is, however, all right if we regard it as but highly probable.

(35) *With various kinds of polished metals no dew is desposited, but with various kinds of highly polished glass dew is deposited Therefore, the deposit of dew is affected by the kinds of substances exposed.* (*Do*).

A Evidently the Joint M. is sought to be applied here.

The argument may be put thus :—When different kinds of highly polished glass are present, there is the deposit of dew , but when different kinds of polished metals are present (and glass is absent), there is no deposit of dew. Since, therefore, dew is deposited on glass, and not on metals, it follows that dew is affected by the *kinds* of substance. In answer to this it may be said that the two sets of instances differ also in respect of the *degree* of polishing ; for metals are polised, while glasses are *highly* polished The deposit of dew may as well be due to this high degree of polish. If so, then the deposit of dew is not affected by *kinds*, but by *degree* Hence the conclusion is not valid

(36) *We observe very frequently that very poor handwriting characterises the manuscripts of able man, while the best hand writing is as frequent with those who do little mental work, when compared with those whose penmanship is poor We may, therefore, infer that poor penmanship is caused by the influence of severe mental labour* (*Do*)

A The argument is evidently based on the Joint Method, and rests on the assumption that able men are necessarily men of severe mental labour It may be put thus .—"In several instances of hard mental labour poor hand writing is present, while in some other instances where severe mental labour is absent poor hand-writing is absent Therefore, severe mental labour is the cause of poor hand-writing" Now, in the first place, we have no justification for assuming that able men are necessarily disposed to hard mental labour Hence there is an undue assumption of premise In the next place, the given connexions are said to be observed *very freqently* The expression *very frequently* suggests that sometimes we observe facts to the contrary, though on extremely rare occasions Hence the Joint Method does not apply The fallacy, therefore, consists in mistaking accidental coincidence for causal connexion, arising from the misapplication of the Joint Method.

(37) *We should think it a sin and a shame if a great steamer, dashing across the ocean, were not brought to a stop at a signal of a distress from a mere smack. And yet a minor is entombed alive, a painter falls from a scaffold, a brakeman crushed in coupling cars, a merchant fails, falls ill and dies, and organised society leaves widow and child to bitter want or degrading alms.* (*I. A*, *19*).

A It is a sin and a shame on the part of the steamer in question, because it deliberately lets slip the chance of rescuing a distressed smack. But no question of such deliberate omission on the part of any one may arise when a minor is entombed or a painter falls, for a mishap of such description may preclude the possibility of help, as being unexpected and instantaneous. The case of smack, therefore, is not necessarily on a footing with that of the painter, or the minor, or the like. Hence the desired conclusion is wrong, as being based on false analogy.

(38) *No body can be healthy without exercise, neither natural body nor body politic; and certainly, to a kingdom or state, a just and honourable war is the true exercise A civil war, indeed, is like the heat of a fever, but a foreign war is like the heat of exercise, and serves to keep the body in health* (*Do*)

A A just and honourable war on the part of a state is no doubt a form of exercise but there are other forms of exercise, as involved in education, sanitation, commerce, industry, agriculture, etc. Exercise should be regularly taken in order that it may conduce to health But a just and honourable war cannot be expected to be waged at regular intervals More over, war, however just and honourable, may prove positively ruinous, if the enemy be too powerful Hence the conclusion that such war serves to keep the body politic in health must be held as unjustifiable.

(39) *During the retreat of the Ten Thousand a cutting north wind blew in the faces of the soldiers sacrifices were offered to Boreas, and the severity of the wind immediately ceased, which seemed a proof of the god s causation* (*Do*)

A The argument would be correct if it could be founded on the Method of Difference But, the method is inapplicable here, for in such a highly complex case we cannot be sure that all other circumstances, which may possibly be connected with the particular case, have remained just the same Therefore, the argument comes to this that because the wind ceased *after* the sacrifices to Boreas were offered, therefore it ceased *on account of* those sacrifices, thus committing the fallacy of *post hoc ergo propter hoc*

(40) *It is known by direct experiment that for any given degree of temperature only a limited amount of water can be suspended as vapour, and this quantity grows less and less as the*

temperature diminishes. Therefore, if there is already as much vapour suspended as the air will contain at its existing temperature, any lowering of temperature will cause necessarily a portion of the vapour to be condensed as dew. (*Do*).

A The conclusion gives no new information, being practically the same as the premises It is stated in the premises that at a given temperature the air can contain a limited amount of vapour, and that this amount diminishes with the temperature. From these it is quite apparent that if the temperature of the air be lowered, it must necessarily give off the amount of vapour in excess of the amount which it can contain at its present temperature. The argument, therefore, commits the fallacy of the *petitio principii*.

(41) *He must be an excellent man in all respect, for I have been favourably impressed by his action.* (*Do*)

A That I have been favourably impressed by his action is no sufficient reason why he must be an excellent man, for my judgment may be erroneous. Besides, I might have possibly watched his actions only in a very limited number of cases, from which I am not justified in concluding that that he *must be* an excellent man in *all* respects The argument may, therefore, be said to commit the fallacy of *non sequitur*.

(42). *The great war was followed by an outbreak of epidemic diseases, therefore the war may be taken to be the cause of these diseases.* (*I A* , *20*).

A If we rest our conclusion upon this single premise, then evidently we shall be committing the fallacy of *post hoc ergo propter hoc* We should, therefore, consider whether other great wars were or were not followed by epidemic diseases And if we find it to be so, we should not stop, but consider *a priori* why it should be so Now we can see that in a great war the huge number of deaths inevitably vitiate the air and water, thus leading to diseases Then again war brings in its train famine, which lowers the vitality of men, thereby reducing their resisting power. The conclusion, thus justified by both induction and deduction, must be taken as valid.

(43). *The number of deaths in Calcutta per annum is greater than in Nagpur Therefore, Calcutta is more unhealthy than Nagpur.* (*Do.*)

A The obvious assumption is that if in a locality, say A, the number of deaths is higher than in another, say B, then A is more unhealthy than B. But this assumption is false for several reasons In the first place, A may be much more populous than B. Secondly, there may be much more imported cases of serious diseases in A than in B, in which case A may have higher mortality than B without its being unhealthy. Hence we have here the fallacy of the undue assumption of premise

(44) *The eating of mangoes is the cause of boils* (*Do*)

A This conclusion is evidently false, as can be seen by applying the M of Agreement or the Joint Method For, all mango-eaters do not suffer from boils, nor is it the case that all persons who abstain from eating mangoes are immune from boils.

(45). *One of the soldiers rescued wore an amulet, and this was, no doubt, the cause of his escape.* (*Do.*)

A Because one of the soldiers wearing an amulet was rescued it does not follow that wearing an amulet is the cause of rescue For, many soldiers who did not care to wear amulets were rescued in the past Again, many soldiers who wore amulets had not the fortune of finding rescue. So the conclusion is supported neither by the Joint Method nor even by the M. of Agreement It is, therefore, false The fallacy is that of mistaking an accidental accompaniment for a cause

(46). *A nation, like an individual, must pass through periods of growth, maturity, and decay.* (*Do*)

A [See 18]

(47). *This man must be the thief, for he was in the room whence the article has been stolen, and he came out as soon as I entered the room* (*I. A.*, 21).

A The conclusion is sought to be justified by the M. of Difference But the essential point that is lost sight of is that somebody else might have escaped with the article unnoticed. Hence the conclusion cannot be held as true.

(48) *How glad am I at your success, which I really anticipated! Is it not meet, therefore, that you should give me some reward?* (*Do.*)

A. The evident assumption is that one, who anticipates another's success and is glad at it, is deserving of reward. But this is an undue assumption, for those alone are deserving of rewards who perform some meritorious service. Hence the fallacy is that of undue assumption of premise

(49). *What better explanation can be given of the fact that we can see through glass than that it is transparent ? (Do).*

A Evidently this is a fallacious form of explanation, consisting in repeating the same thing in different words, thus involving the fallacy of the *petitio principii*, for, 'to be seen through' is the same thing as 'to be transparent'

(50). *Induction supported by deduction affords the most conclusive proof Now we see men around us more or less given to evil ways And we also read in our sacred books (the Sastras) that in the present age (Kali Yugo) there would be degeneration of mankind Can, then, there be more conclusive proof of the degeneration of modern times ? (Do)*

A The conclusion claims to be established by observation supported by deduction But the claim is utterly unfounded It is, no doubt, true that we find people round about us addicted to vices But we cannot observe whether or not they are more addicted to vices than people in ancient times, which is the real question at issue. Besides, we have no means of ascertaining the cogency of the deductive argument by which the makers of the *sastras* drew the given conclusion. Hence this is not a case of induction aided by deduction, and so we cannot accept the conclusion as true

(51) *Is not dirt washed away by a current of water ? Yes Then, is it impossible that all the sins of omission and commission may be washed away by the holy water of the Ganges when one dips into it ? No Thus, it matters little how one acts or thinks so long as he periodically bathes in the Ganges (Do).*

A This is an argument from analogy. The argument is just this :—Just as physical dirt is washed away by water; so sin (which is spiritual dirt) is washed away by the water of the Ganges The resemblance is but figurative, and that is not even carried far enough, for the true conclusion, according to figurative analogy, is that sin (spiritual dirt) is washed away by spiritual water, and it is the tears of repentance, and not the water of the Ganges (which is in every sense physical water), that may be regarded as spiritual water. Hence it is an instance of bad analogy

CHAPTER XX.

GENERAL EXERCISES.

179 Q *'An eclipse of the sun will occur when the moon intervenes between the earth and the sun,' an eclipse of the sun will occur when some great calamity is impending over mankind Examine the logical grounds and comparative validity of the above two propositions* (*I A*, *10*).

A The first proposition is based on the M of Difference It may be also verified by deductive calculation Because the moon is an opaque body, it necessarily follows that when it stands between the earth and the sun, the intercepted portion of the sun will be invisible, Hence the conclusion is certain

The second proposition is a false generalisation based on non-observation, *i e*, overlooking the negative instances

180 Q *All arsenic is poisonous, the substance before me is arsenic, it is therefore poisonous, explain the logical process underlying* (i) *your belief in the major premiss*, (ii) *your belief in the minor premiss, and* (iii) *the conclusion drawn* (*Do*)

A. (i) The major premiss is an induction per simple enumeration, and as such, my belief is based on uncontradicted experience.

(ii) I believe the substance before me to be arsenic, because it resembles what is known as arsenic in essential points, *e. g*, colour, taste, smell, and various chemical properties Hence the inference that it is arsenic is based upon deep seated resemblance (or according to the realists, upon identity).

(iii) When the major and minor premises are established, the conclusion follows from them syllogistically [According to Mill, the conclusion is not drawn from the major premiss, but from the particular cases in which arsenic was found poisonous]

181 Q *What kind of Logic is applied by* (i) *the engineer when he is designing a new bridge*, (ii) *the physician when he is prescribing a particular medicine to a patient, and* (iii) *the legislator when he is introducing a new law?* (*I. A.*, *11*).

A. In designing a new bridge, the engineer has to take into account various circumstances, such as the depth and the width of the river, the force of current, the purpose for which the bridge is to be used, and so forth Now, the established rules of engineering are not enough to cover all such cases. Hence he has also to depend on his own experience. Thus, his Logic will be both inductive and deductive.

In prescribing a medicine the physician is to diagnose the disease from the symptoms, and then prescribe the medicine, as directed by the medical authority. Hence his Logic will be deductive. But when a physician makes experiment to see whether a particular medicine is or is not suitable in a particular case, his Logic is inductive

In introducing a new law, the legislator has to observe the effects which similar laws produced in other countries under similar circumstances Then he is to calculate the probable effect which the new law will produce upon his people, judging it from the nature of those people Hence his Logic will be both inductive and deductive.

182 Q *'I have noticed,' says Mr Tsien, 'that in years of plenty many good actions are done, and in years of scarcity many bad actions are done' What is the inference evidently implied here? Express it in its simplest form, showing under which of the logical methods it falls, and indicate its logical value as inference.* (*Do*)

A. The evident inference is that poverty is the cause of bad actions , for when poverty is, bad actions are, and when poverty is not, bad actions are not Hence the argument is based on the Joint method But as we cannot expect the negative instances to be exhaustive in such a complicated case no causal connection can be inferred with any degee of certainty

183 Q. *"We think that as civilization advances poetry almost necessarily declines Therefore, though we fervently admire those great works of imagination which have appeared in dark ages, we do not admire them the more, because they have appeared in dark ages" State in full logical form the reasoning involved, and test it fully* (*Do.*)

A. The argument may be tested by throwing it into the syllogistic form :—

Whatever *necessarily* flourish in dark ages are not all the more admirable, because they flourish in dark ages (Major)

Poetry is what *necessarily* flourishes in dark ages (Minor). Therefore, poetry is not all the more admirable, because it flourishes in dark ages (Conclusion)

Now, as the argument is in Celarent, the *process* of reasoning is all right Let us examine the premisses The minor premiss is not only based upon experience, but also confirmed by deductive calculation, for from the nature of the case it follows that imagination declines with the advance of civilization, as the struggle for existence increases, and the practical needs of life more and more engross the attention of the people Hence the minor premiss is certain As regards the major premise, it is a matter of opinion, and as such men will differ with respect to its truth Hence the conclusion will be true or not according as the major premiss is true or not

184 Q *The more the number of pools of stagnant water in a district is reduced, the rarer does the occurrence of malarial fever become. What conclusion can be drawn from the above statement? State the reasoning implied in its full logical form, exhibiting the logical method applied in it, and estimate the logical value of the inference* (*Do*)

A The conclusion is that stagnant water is the cause of malaria, for they vary in a corresponding way The argument is evidently based on the M of C Variations Now, because this method cannot prove a causal connexion with certainty, all that we can infer is that either stagnant water is the cause of malaria, or both are the co effects of a common cause

185 Q *You believe that Siraj ud doulah took Calcutta from the English in 1756 – State on what grounds you believe this proposition, and exhibit their logical character* (*I A , 12*).

A I believe it on the authority of the historians [As for the nature of authority, see ch I]

186 Q *A bell struck in a vacuum gives no sound, therefore sound must be a movement of the atmosphere. Exhibit the logical character of the reasoning here* (*Do*)

A. This argument is based on the M. of Difference, for when air is, sound is , and when air is not, sound is not. And as we know that the other conditions, which may possibly be connected with this case, remain the same, the argument is all right.

187 Q. *It is a popular belief that there will be a change of weather at new moon : what logical process would be required to establish the validity of this belief?* (*Do.*)

A. First, we should observe carefully whether this is the case or not. If it is observed to be true in numerous instances, we should next calculate why it should be the case If we can find out satisfactory reasons for that, then the belief will be regarded as valid.

188 Q. *"When beggars die, there are no comets seen The heavens, themselves blaze forth the death of princes" Characterise logically the grounds of this belief.* (*Do*)

A When beggers die, no one cares to notice their death. Again, sometimes comets accidently appear at princes' death, and men mark the coincidence , but they overlook the numerous instances in which they do not appear. Hence the belief is fallacious due to non-observation.

189 Q *'Every man who has seen the world knows that nothing is so useless as a general maxim'. Estimate this logically, pointing out what would be necessary for logically establishing this proposition.* (*Do*)

A The expression means that every practical man knows that a general maxim is most useless. As it is the knowledge of a *practical* man, it is obviously based upon mere experience, *i. e*, it is an induction per simple enumeration, and as such its truth is not unquestionable

Bare experience is not enough to establish the proposition that general maxims are useless in practical life. We must consider why that should be the case, *i e*, we must verify it by deductive calculation (induction aided by deduction) Now, we see that very often in practical life urgent problems arise which demand immediate solution. In such a situation, men stocked with maxims will take time to deduce conclusions from their pet maxims, and thus lose the job ; while a man with practical insight will immediately solve the prob lem. Hence it follows that in practical affairs maxims are useless. Thus we see that to establish this proposition experience must be aided by calculation—induction aided by deduction.

190 Q. *Suppose that wherever there are anopheles mos-*

quitoes, there is malaria, but malaria is found also where there are no mosquitoes; what conclusion can you draw from this? (*I. A.*, *13*).

A. We cannot apply the M. of Agreement here, for instances do not agree in the presence of the two phenomena, *viz*, mosquitoes and malaria, Nor can we apply the Joint Methed, for mosquitoes are absent in the second set of instances, but malaria is not absent. Obviously, no other Exp. Method is applicable We cannot, therefore, infer with any degree of certainty that mosquitoes are the cause of malaria. Such a conclusion will be a probable one, the degree of probability being determined by the number of instances of the conjunction of two phenomena, as compared with the number of instances where there is no such conjunction

191 Q *Water freezes to-day at 32° 'F. therefore it will freeze at 32° at this time next year, explain the logical character and value of this.* (*Do*)

A The conclusion is an unwarrantable extension of a secondary law beyond the narrow limits of time and place, and hence is likely to be fallacious. For, there is no knowing that the conditions obtaining to day will hold good at this time next year The uniformity of nature does not mean that the same day of the same month of different years, the same conditions will prevail. It may be that the atmospheric pressure will differ at this time next year. In that case water will not freeze exactly at 32° at this time of the next year.

192 Q *It is a common hypothesis in Bengal that railway embankments are the cause (proximate or remote) of malarial fever What logical processes would be required to prove or refute the hypothesis?* (*Do*).

A We should first apply the M of Agreement in order to be convinced of the high probability of the given hypothesis And if we find in numerous instances that all the places, where railway embankments have been constructed, have been visited by malaria, then we shall apply the Joint Method in order to ensure the conclusion And if we see that the places where there are no such embankments are free from the scourge of malaria, we should regard the conclusion as very much approaching certainty But with a view to rest the conclusion on a sounder basis we ought to calculate *a priori* why that should be the case. We may reason thus :—" Railway embankments cause stagnation of water, and stagnant water causes mosquitoes, which are known to be the cause of malaria. Hence we see how such embankments are the remote cause of malaria." Thus the hypothesis may be proved by combined induction and deduction But if the hypothesis cannot stand all those tests, then it must be discarded.

193 Q. *Yesterday the smoke of the chimney tended to sink downwards, and it rained in the afternoon: can any connection be inferred from this?* (*Do*).

A. The fact that smoke tended to sink downwards indicated that the pressure of the atmosphere was less than normal which is the case when air is charged with plentiful vapour. Hence the atmosphere was vapoury yesterday, and the natural consequence was that there was rain. But the sinking of the smoke should not be regarded as the cause, but only as a sign of rain.

194 Q *When Crusoe saw the print of a bare foot on the sandy shore, he thought at once that savages had landed on his island Give a logical analysis of Crusoe's thought.* (*Do.*)

A. Crusoe thought thus :—Since it is the print of a *bare* (unshod) foot, it must be the footprint of a savage, for the civilized people do not travel unshod Next, from a single foot print, it is not to be presumed that only one savage having a single leg has landed on the island Savages do not roam alone, but in groups so as to be able to execute their dark designs. Hence a good many savages must have landed, but their footprints, being on a sandy shore, have been effaced ([illegible]

C U. Questions.

[With references and brief answers

(1922)

1 Distinguish between *deduction* and *induction*, their scope and functions.

Explain what sort of logic is used in order to make the following statements :—(*a*) The heat of June is followed by the refreshing showers of July. (*b*) Homer is the common property of all later poets. (*c*) Plants must breathe in order to live.

[(*a* & *b*)Inductions per simple enumeration, for based on uncontradicted experience (*c*) Inference from analogy. The argument is just this ·—Plants resemble animals in respect of origin, growth, decay, and death, therefore, there must be resemblance also in respect of breathing]

2. What is meant by the *cause* of an event ? How does a cause differ from conditions ? A balloonist, unable to make a successful parachute descent, falls headlong and dies. Determine clearly the cause and conditions of his death. [Q. 32.]

3. *Either*, What are the various canons of elimination ? Show, by concrete examples, how each of them furnishes a method of enquiry into causation [Q. 71.]

Or, What is meant by *varying the circumstances* in scientific investigation ? Discuss, giving illustrations, the use and necessity of this process. [Q. 15]

4 *Either*, Explain the nature, modes, and limits of *logical explanation* What is its relation to hypothesis and induction ? Contrast the scientific conception of explanation with the popular [Chap XI]

Or, Discuss the nature, value, and uses of *analogical reasoning* How does analogy differ from induction and generalisation ? [Chap. IX].

5. *Either*, Distinguish between *observation* and *experiment*, and explain their importance in Inductive Logic. Discuss the comparative advantages and disadvantages of these two processes [Chap. V]

Or, Explain and illustrate four of the following —Plurality of Causes, Intermixture of Effects, Law of Nature, Empirical Law, Working Hypothesis, Necessary Truths [QQ 39, 33, 98, 100, 121, 161].

6. Distinguish between *non observation* and *mal-observation*, giving concrete examples of their various forms. State your opinion as to which is more common in actual life [Q. 175].

7. Test any four of the following arguments :—

(a) The non co-operators should not boycott the university, for their leaders are all educated men.

(b) The Reforms have given a death blow to Bolshevism in India, for the people are now looking forward to a better state of things

(c) Life is but light, and no wonder that a man should be cut off in the prime of life ; a light burning brightly is very often put out by a puff of wind.

(d) The university is the Temple of Learning, and therefore politics has no place in it.

(e) We should not mourn the death of eminent men, for by the law of the survival of the fittest those that are still alive must be fitter and better than those that are gone

(f) Oh, I would give the whole world for peace of mind, for that is really invaluable.

(g) I do not consult physicians, for those that do so also die

[(a) Because the leaders are educated, it does not follow that they should not preach the boycott of the university Being themselves educated, they are in a position to judge of the merits of the university education And if they are convinced that such education is productive of useless or injurious results, they may well ask their followers to boycott the university and follow more suitable lines of occupation Hence the argument commits the fallacy of *non sequitur* (b) Falsity of premiss, for the people are rather growing more and more despondent and desperate (Discuss this) (c) False analogy, based on figurative resemblance (Discuss). (d) Undue assumption of premiss, for the assumption is that politics has no connexion with learning, whereas, as a matter of fact, we learn a good deal from politics (e) The law of the survival of the fittest cannot rightly be dragged down to individual cases. A may be far fitter than B, but still may predecease B. Hence falsity of premiss (f) The assumption is that the whole world may be sacrificed for something invaluable There is nothing wrong in such an assumption Hence if the exclamation may be regarded as an argument at all, it is all right. (g) The evident conclusion is that physicians are not worth consultation But, from the fact that some of the patients attended by the physicians die such a conclusion does not follow (say why). Hence the fallacy of *non sequitur*].

[1923]

1. Is Inductive Reasoning merely the converse of Deductive Reasoning? Fully discuss this question, and in this connexion bring out clearly the relation of one to the other.

2 *Either*, Distinguish between Perfect and Imperfect Induction, and discuss the question whether perfect induction is demonstrative and syllogistic, while imperfect induction is neither. [Q. 18 Perfect induction, being a mere summation of particular facts, is no reasoning at all, whether inductive or deductive Imperfect induction is what we mean by induction, which is not obviously demonstrative (See Q 164)]

Or, Can Inductive methods be correctly divided into methods *either* of observation and methods of explanation, *or* into these and Experimental methods? [The question is nonsensical, to say the least of it]

3. *Either*, When is it necessary to employ the Joint method of Agreement and Difference? Give a concrete example of the application of this method [Q. 58]

Or, A man goes out into the open air where a cold breeze is blowing, and gets a cold What is the cause of his getting a cold (a) from the practical point of view, (b) from the scientific point of view? Fully explain the scientific conception of causation. [Q 32]

4 Explain fully, with illustration.—(a) The difference between fact and theory, (b) *vera causa* and crucial experiments. [QQ 121, 126, 128].

5 What precisely is the relation of Hypothesis to Explanation? What are the different forms of scientific explanation? State and illustrate them. Is explanation possible in every case? [QQ 111, 11 , 114].

6. *Either*, Examine the view that 'the ground of all

induction is itself an induction', and mention the conditions of inductive inference. [QQ. 25, 29].

Or, Explain classification by definition, by type, and by series. Give a concrete example of each. What, in this connexion, is the point at issue between Mill and Whewell? Which of them do you think to be correct, and why? [QQ 135, 140].

7. Test any three of the following arguments :—

(a) Green colour is found only in the surface region of plants. If one cuts across a living twig, the green colour will be seen only in the outer part of the section. Hence the green colour of the plants holds some necessary relation to light.

(b) Tyndall found that of twenty-seven sterilised flasks containing infusion of organic matter and opened in pure Alpine air, not one showed putrefaction; while of twenty-three similar flasks, opened in a hayloft, only two remained free from putrefaction after three days He concluded that putrefaction is due to floating particles in the air.

(c) Linnets, when shut up and educated with singing larks, will adhere entirely to the songs of those larks, instead of the natural songs of the linnets. Hence we may infer that birds learn to sing by imitation, and their songs are no more innate than language is in man.

(d) Vesalius found that human thigh bone was straight, and not curved, as Galen had asserted Sylvius replied that Galen must be right; that the bone was curved in its natural condition, but that the narrow trousers worn at the time made it artificially straight.

(e) States that have grown outrageously luxurious have declined in power. Hence we conclude that luxury was the cause of their downfall -

[(a) Misapplication of the Joint method. The conclusion would have been right if it could have been shown that whenever the surfaces of the leaves are exposed to light they contract green colour, and whenever not so exposed, no green colour. (b) The M. of Difference applied here. When the contents were exposed to air containing floating particles, there was putrefaction, and when exposed to air not containing such particles, no putrefaction. Now, if it was sure that there was nothing in the contents of the former flasks which might have led to putrefaction, then the conclusion is all right (c) This is an induction per simple enumeration, but based on a very limited scope of experience A sweeping generalisation is arrived at after an examination of a number of linnets only Besides the fact that linnets can be taught to imitate the songs of other birds does not prove that they have no instinct of singing, for we know that instinct, though inborn, may be suppressed by habit Hence the conclusion is wrong (d) Galen's conclusion must be right, if the asssumption that a curved bone can be made straight by wearing narrow trousers be right But such an assumption is not borne out by our experience. Hence undue assumption of premiss (e) The argument is evidently based on the M. of Difference When luxury was the downfall was, and when luxury was not, the downfall was, not, hence luxury was the cause of the downfall This conclusion, thus arrived at inductively, is borne out by deductive considerations also, for if a nation is outrageously luxurious, it grows dead to real progress, and hence declines and falls]

[1924]

1 *Either*, Explain the meaning and scope of Induction, distinguishing it from processes which are improperly called inductions Show, by a concrete example, that inductive inference admits of being thrown into the deductive form [QQ 13, 18, 19, 21, 171

Or, Explain your view of the relation of Induction to Deduction Which of these is the prior process, and on what grounds do your think it to be so ? [Q 171]

2 *Either*, 'Observation and Experiment constitute the *material* ground of Induction. The law of the uniformity of Nature is the *formal* ground of Induction' Fully explain this [Q 25]

Or, Explain the nature of Observation and Experiment What are the advantages and the disadvantages of each process ? [QQ. 42, 43.]

3 *Either*, Explain the distinguishing marks of a cause In a locality there has been a sudden outbreak of crimes, how would you proceed to investigate into the outbreak ? [Q 31 The question of investigation into a particular case of causation falls outside the scope of Logic, and as such should not have been asked].

Or, Fully explain what is meant by (a) Plurality of Causes, and (b) Intermixture of Effects How do they tend to frustrate the application of the experimental methods? And what are the remedies by which the difficulties created by them are overcome? [QQ. 39, 33, 49, 73]

4 *Either*, Explain, giving a concrete example, the Method of Difference, and point out its relation to the Methods of C Variations and Residues. Explain the nature of phenomena for the investigation of which the last two methods are particularly suited [QQ 54, 54, 67. The M. of C variations is specially applicable to those phenomena known as permanent causes (Q 61) It is not, however, understood to which class of phenomena the M. of Residues is particularly applicable]

Or, Explain the nature of Hypothesis What are the chief requisites of a valid hypothesis? Indicate the place of hypothesis in inductive reasoning [QQ 118, 121].

5 Explain Classification, natural and artificial. Is classification by *definition*, or by *type*? Discuss this. [QQ. 135, 140].

6 *Either*, Explain what is meant by a Law of Nature. How would you classify the laws of nature? Why should laws of nature be expressed as *tendencies* only? [QQ 98, 100, 102 The meaning of the last part of the question is not clear. It is urged that all laws should be expressed as tendencies Some laws are, no doubt, expressed as tendencies, e g, 'All bodies *tend* to fall to the earth' All bodies tend to behave in some particular ways. But these tendencies may be counteracted, so that though they may not always behave in those ways, they tend to do so Hence perhaps it may be said that the laws of nature should be expressed as tendencies]

Or, Enunciate and explain the canons or principles which underlie the experimental methods Give concrete illustration. [Q 71]

7 Examine any four of the following as inductive arguments :—

(a) All bats are birds, for they have wings

(b) Wine cannot be injurious to health, for if it were so, the Doctors would not have prescribed it

(c) Unfortunately all the men with whom I have been acquainted are selfish, how can I resist the conclusion that all men are selfish ?

(d) The anatomical resemblance between men and apes is marvellous, and from such resemblance we may safely conclude that men are descended from apes

(e) My friend must be a genius, for he has many eccentricities, as all geniuses have

(f) The Professor must be a very learned man, for his words are so big and hard that very few understand them.

(g) All religions lead to God, for do not all roads lead to Rome, and all rivers fall into the sea ?

[(a) The assumption that all winged creatures are birds is false Hence undue assumption of premise (b) The Doctors prescribe wine only in cases of certain physical derangements In some such cases they prescribe poisonous drugs also, from which, indeed, we cannot argue that poisonous drugs are not injurious to health The fact is that what is suitable in a diseased state is not generally suitable in health Hence the argument is fallacious, (c) This is an induction per simple enumeration But it is based on a very limited range of experience, and I have not evidently tried to enlarge the scope of observation Hence the conclusion is unreliable (d) From mere anatomical resemblance between, say A and B, the descent of B, from A cannot be inferred, for A may as well be supposed to descend from B, or both A and B may be supposed to descend from a common stock, or the resemblance may be supposed to be accidental Hence the argument is fallacious, as ignoring the plurality of causes, for the resemblance may be due to various causes (e) From the fact that all geniuses have eccentricities it does not follow that whoever has eccentricities is a genius Hence the fallacy of *non sequitur* (f) Undue assumption of premise, for big and hard words are not necessarily the sign of deep learning (g) Even if it be granted that all roads lead to Rome and that all rivers fall into the sea the conclusion does not follow that all religions lead to God, for the argument is based on a figurative resemblance of an extremely flimsy character. But as a matter of fact, all roads do not lead to Rome, nor do all rivers fall into the sea Hence the argument is false]

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